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# PROCEEDINGS

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OF THE

111

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OF LONDON.

(pt. 3-4)

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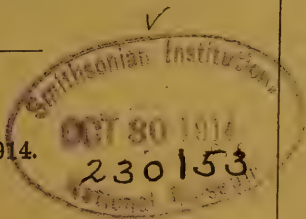
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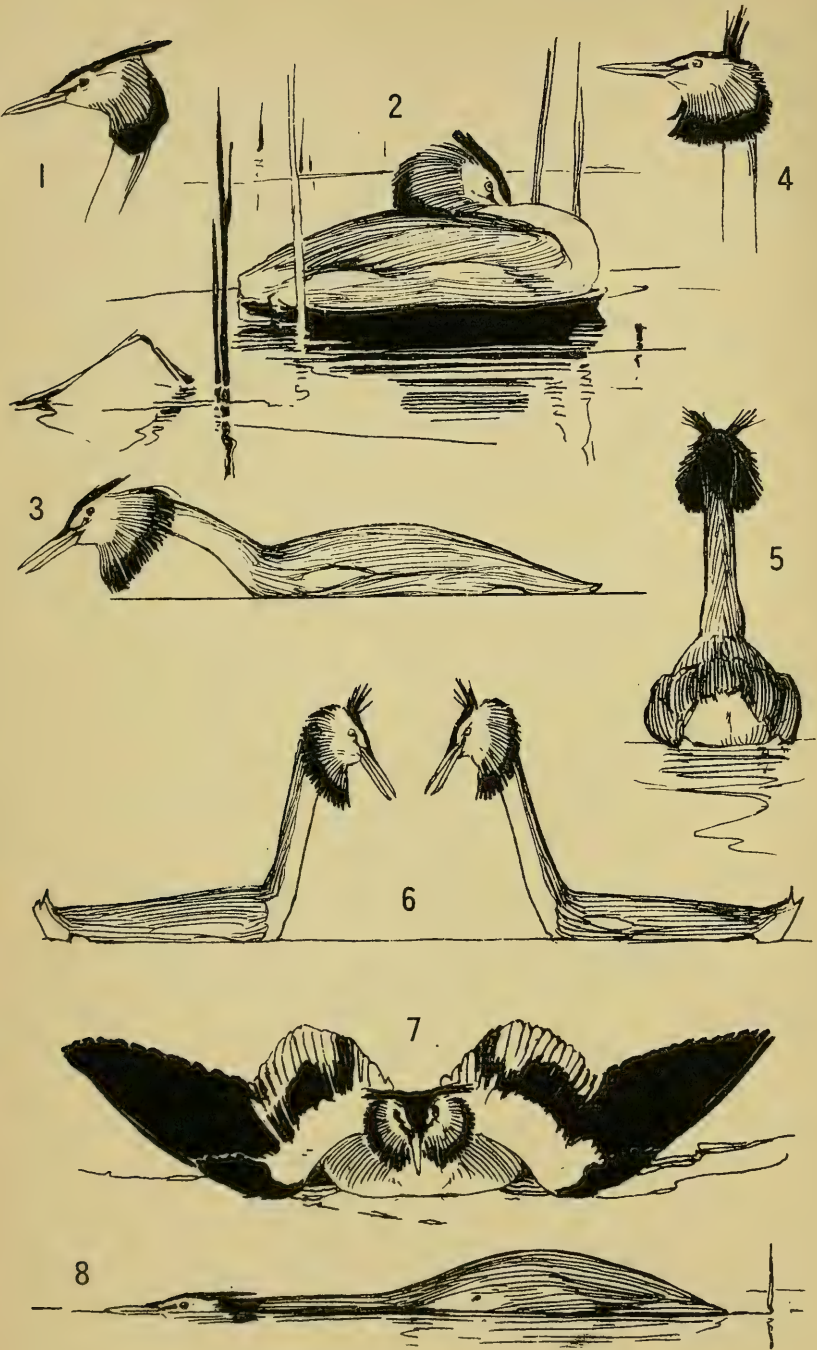
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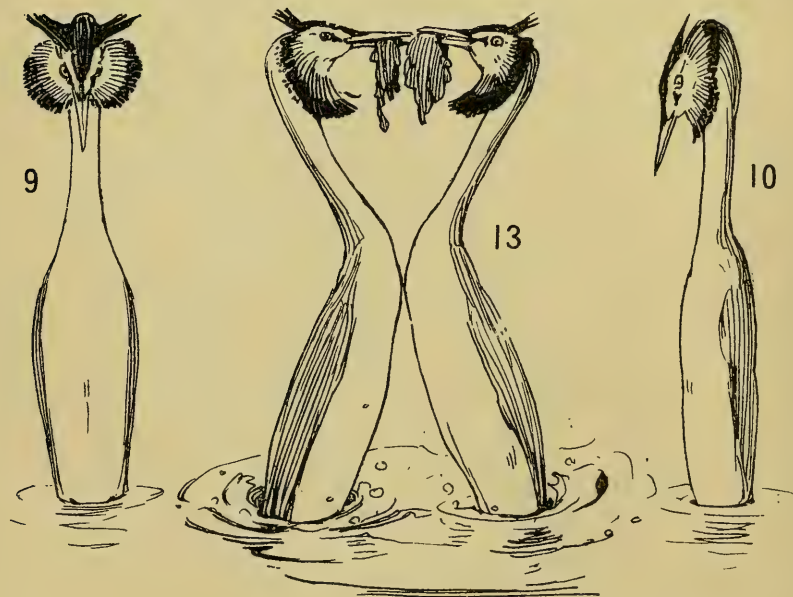




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COURTING-HABITS OF *PODICEPS CRISTATUS*.





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PROCEEDINGS  
OF THE  
GENERAL MEETINGS FOR SCIENTIFIC BUSINESS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.

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PAPERS.

33. The Courtship-habits\* of the Great Crested Grebe (*Podiceps cristatus*); with an addition to the Theory of Sexual Selection. By JULIAN S. HUXLEY, B.A., Professor of Biology in the Rice Institute, Houston, Texas †.

[Received March 14, 1914: Read April 21, 1914.]

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\* It was not until this paper was in print that I realized that the word *Courtship* is perhaps misleading as applied to the incidents here recorded. While Courtship should, strictly speaking, denote only *ante-nuptial* behaviour, it may readily be extended to include any behaviour by which an organism of one sex seeks to "win over" one of the opposite sex. It will be seen that the behaviour of the Grebe cannot be included under this. "Love-habits" would be a better term in some ways; for the present, however, it is sufficient to point out the inadequacy of the present biological terminology.

† Communicated by the SECRETARY.

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## PART I.

### 1. INTRODUCTION.

In these days the camera almost monopolizes the time and attention of those who take an interest in the life of birds. It has rendered splendid service, but I believe that it has almost exhausted its first field. At the present moment both zoology and photography would profit if naturalists for a little time would drop the camera in favour of the field-glass and the note-book. For the many who do not care about using a telescope, the prismatic binocular has more than doubled the possibilities of field-observation; and when full advantage shall have been taken of those possibilities, not only will science be the richer for a multitude of facts, but then, and only then, will the photographer, now hard-pressed for new subjects, suddenly find a number of fresh avenues opened up to him.

This second paper on the courtship-habits of British birds, like the first, will, I hope, help to show what wealth of interesting things still lie hidden in and about the breeding places of familiar birds. A good glass, a note-book, some patience, and a spare fortnight in the spring—with these I not only managed to discover many unknown facts about the Crested Grebe, but also had one of the pleasantest of holidays. “Go thou and do likewise.”

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I shall first give a connected account of my own and others' observations, followed by a discussion; and in a second part or appendix I shall give in detail some of the material worked up in the first part, as well as some notes on various points not connected with the main subject of the paper.

### 2. APPEARANCE.

Structure first, function afterwards: I must describe something of the bird's appearance before attempting to give an account of its habits, though I shall try to be as brief as possible, since any

standard work of descriptive ornithology will give full details of the plumage and taxonomic characters. The Great Crested Grebe, then, is of course a water-bird, and essentially a diving-bird. Its tail is remarkable in being reduced to a few tiny feathers, and its legs are set as far back as possible, so as to have the position of a ship's propellers. Its body is long and approaches the cylindrical; the neck is very long and flexible, the head flat, the beak sharp, long, and powerful. In colour, the Great Crested Grebe has back and flanks of much the same smoky mottled brown as its small cousin, the Dabchick; the underparts, however, including the chin, throat, and front of the neck, are of an exquisitely pure white (furnishing the "Grebe" of commerce). The back of the neck is very dark brown.

The chief ornament of the bird, the crest from which it takes its name, is reserved for the head. In these pages I shall use the word *crest* to denote *all the erectile feathers of the head taken together*. The crest, as thus defined, consists of two parts—the *ear-tufts* (or *ears*, as for brevity's sake they may be called) and the *ruff*.

Both are composed of special narrow, elongated feathers, stiff, and formed of comparatively few barbs. Those constituting the ears are black, all of about the same length, and spring in two tufts from the top of the head, above the tympanum. The ruff is bigger and more elaborate: it consists of a broad band of feathers springing from the sides of the face and head, their free ends pointing downwards and backwards on either side of the neck. If we take the part of the head behind the eye, we find that at first the feathers are of the ordinary length, then slightly elongated (the beginning of the ruff), and then longer and longer till we get to the hinder border of the ruff. Corresponding to the increase of length there is a change in colour. The proximal (upper) part of the ruff is white, then we get to vivid chestnut, and this deepens gradually to glossy black (see any good picture of the Crested Grebe).

Both ruff and ears are extremely erectile; and as the birds make great play with them during all the actions of courtship, the various positions into which they can be put must be described.

Let us begin with the ears. These, when depressed or shut, stretch straight out backwards, continuing the line of the flat head's crown. When shut forcibly, the feathers of which they are made are close together and all parallel.

Often, however, they are not thus "at attention," but "standing at ease," to use a military metaphor: then the tufts as a whole point in the same direction, but their component feathers diverge and bristle-out a bit. This seems to be the usual and most restful condition.

Further, the tufts may be erected: and they may be erected in two ways—either *laterally* or *vertically*. When erected laterally, they stick out horizontally at right angles to the head, so that

from the sides they can scarcely be seen, as they are end-on to the eyes. When erected vertically, they seem, when viewed from the side, to be sticking straight upwards; but when they are seen from in front, it is found that they diverge from each other at a considerable angle (Pls. I. & II. figs. 4, 5, 11). During erection, the individual feathers always diverge fanwise very considerably. Thus there are four conditions of the ear-tufts to be distinguished.

They may be:—(a) *Depressed*.

(1) *Shut tight*.

(2) *At rest* (relaxed).

(b) *Erected*.

(3) *Vertically*.

(4) *Laterally*.

The ruff is more complex in its attitudes, as in its structure. During depression it, too, may be either shut tight or lying easy. When really shut, it bears from the side a curious resemblance to the gill-covers of some eel-like fish: its rounded hinder border lies along the side of the cylindrical neck, whose outlines its own scarcely overlap, either dorsally or ventrally (fig. 1). When relaxed (at rest), this resemblance disappears, for the feathers all diverge slightly, and the smooth appearance of the surface is lost.

When the ruff is erected, the feathers composing it may be made to diverge in a single plane only, the original (longitudinal-vertical) plane of the "gill-cover," or they may diverge outwards as well, making an angle with the side of the head (movement in the transverse, as well as the sagittal plane). I do not think that they are ever moved in the transverse plane alone. As a result of these movements, three chief forms can be taken on by the ruff. First there is the *curtain form*, in which motion in the vertical plane alone takes place, the ventral edge being brought forward till it makes an acute angle with the line of the chin (fig. 3), the two halves thus hanging like curtains on either side of the head. Then there is the *pear-shaped* condition (figs. 4, 11), where there is a considerable amount of forward and a moderate amount of transverse motion. The ruff in this state has its vertical height greater than its breadth (fig. 5). Owing to the transverse bristling of the feathers, the two halves of the ruff almost blend into a single whole; they can scarcely be distinguished either from the front or, still less, from behind, whereas in the curtain form they are very distinct. Finally, there is the *elliptical form*, when, added to the same amount of longitudinal motion, the greatest possible amount of transverse bristling has taken place. The ruff is now actually broader than it is high (fig. 9), and the blending of the two halves is practically complete. There are, of course, intermediate states. Instead of "full pear-shaped," you may have "half pear-shaped"; and between pear-shaped and elliptical there comes the *circular*.

The three I have named, however, are those which the bird usually adopts.

The ruff, therefore, may be:—

(a) *Depressed*.

(1) *Shut tight* ("gill-cover").

(2) *At rest* (relaxed).

(b) *Erected*.

(3) *Curtain-like* (motion of feathers in one plane).

(4) *Pear-shaped* } (motion of feathers in two planes).

(5) *Elliptical*

By a combination of particular positions of ruff, ears, and neck, and sometimes wings and body too, the birds can assume a number of characteristic and often-recurring *attitudes*, which are the raw materials, so to speak, of all the elaborate *habits of courtship*.

Before giving any more definitions, I will now give an outline of the Grebe's annual history, and then go on to describe some of the actual happenings that I saw, in order to give an idea of the problems to be solved. Then I shall try to define and classify the various courtship-habits, and discuss the general bearing of the facts.

### 3. ANNUAL HISTORY.

This is somewhat as follows\*. About the first week of February they leave the sea-coast and fly back in bands to the inland waters where they breed. They live in flocks for about three weeks, and then start pairing-up. Pairing-up lasts altogether about a fortnight, bringing us to mid-March. From this time on to the end of summer, the unit is neither the flock nor the individual, but the family, represented at first by the pair. About the beginning of April nest-building begins, and by the end of the month every nest will have eggs. The family parties live together through the summer, though apparently the cock leaves the hen to look after the young when they are half-grown (Pycraft, '11). There is usually no second brood unless the first is destroyed. At the end of September they gather into flocks again, and live thus for well over a month, finally leaving for the sea-coast in the second week of November.

The period of pairing-up itself I have unfortunately not been able to observe; the keeper tells me that there is much flying and chasing about. The part played by the "courtship" in the actual pairing-up is thus left uncertain. From analogy with other birds and with ourselves we should expect that the chasing was the expression of felt but unreasoned likes and dislikes, and that the courtship-actions were only gone through *after* the two birds had become fairly well-disposed towards each other. The courtship-

\* The dates refer to the movements of the birds at Tring Reservoir, and have been given me by the head-keeper there.

actions, I am told, are at any rate to be seen immediately after pairing-up.

#### 4. SOME DESCRIPTIONS.

(a) Let us start with the commonest of all the scenes of courtship—the one which had first attracted and puzzled me years ago, and led me to choose the Grebe as a bird to watch.

As the birds ride on the water, very little of their under-surface is usually visible; but now and then a twinkle of white is seen. This may be merely a bird rolling half over to preen its belly; but if it proceed from two birds close together, this form of courtship is almost sure to be in progress. In such a case, the glass reveals that the two birds are always a pair, cock and hen; they are facing each other, their beaks perhaps a foot, perhaps a mere couple of inches apart, their necks held up perfectly straight and elongated to a truly surprising extent. It is this holding up of the neck that shows some of the white of throat and breast. Their ears are erected vertically and their ruffs are full pear-shaped. The few little feathers that do duty for a tail are cocked up as far as they will go—that is to say, about half an inch (fig. 11).

In this attitude the birds proceed to go through a curious set ritual.

Let us describe a particular case. A pair of birds, cock and hen, that had been fishing not far apart, suddenly approached each other, raising their necks and ruffs as they did so, till by the time they had got face to face they were in the attitude I have just described. Then they both began shaking their heads at each other in a peculiar and formal-looking manner. Each bird began by wagging its head violently from side to side, some four or five times in quick succession, like a man nodding emphatic dissent. Then the quick side-to-side motion gave place to a slow one, and the beak and head were swung slowly across and back, with a seemingly vague and enquiring action, as if the bird were searching the horizon for it knew not what. The head was moved back and forth perhaps a couple of times, and then the violent shaking began again. This alternation of shaking and slow side-to-side swinging was repeated over and over again by each bird: strangely enough, the pair kept no time with each other—the violent shakings of the two neither coincided nor alternated, but each shook and swung without any apparent reference to the other's rhythm.

After six or seven repetitions of the performance another action came in. After the slow swing and before the wagging (or sometimes, I think, taking the place of the slow swinging), but not every time, the bird bent its neck right back and down as if to preen its wings, put its beak under some of the wing-feathers near the tail, raised them an inch or so, let them fall, and brought its head swiftly back into position for another of the violent shakings. This action had obviously something to do with

preening, but had an extraordinary look, as of a stereotyped and meaningless relic. The birds seemed to be performing some routine-action absent-mindedly and by mere force of association, as one may sometimes see a man wind up his watch in the day-time, just because he has been changing his waistcoat.

Finally, after each bird had given about a dozen or fifteen violent shakes, with a corresponding number of slow swings and liftings of wings in between, they veered up into the wind almost simultaneously, lowered their crests, brought their necks down, and, in a word, became normal once more both in appearance and behaviour.

One must have names for things if one is going to discuss them, as any philosopher will tell you. So I propose to call a whole performance such as that just described *a bout of shaking*; each little time of violent wagging I shall call simply *a shake*, and shall measure the length of a bout by the number of shakes in it (counting the shakes of both birds added together). Finally, the curious actions resembling preening I shall call *habit-preening*, because I believe them to have (or rather, to have had) something to do with real preening, but, in the performance as gone through to-day, to have become a mere habit, vestigial so far as its original function is concerned.

(b) That is one little scene: now take another.

A solitary bird, which proved to be a hen, came flying over from one reservoir to another. She alighted near one shore and began swimming slowly across towards the other, meanwhile alternating between two attitudes.

First of all she arched her neck right forward till the bill, which pointed slightly downwards, was just above the water. The ears meanwhile were scarcely erected; the ruff was thrown forward in curtain-form, and thus, since the head had been brought so far forwards and downwards, actually swept the water on either side (fig. 3). So she progressed, looking from side to side, and now and then giving a short barking call. After four or five of these calls, which represented perhaps 20 or 30 seconds of time, she put down her ruff and raised her neck nearly straight up to enlarge her circle of vision.

After some seconds of looking about her in this position, she relapsed again into the first attitude—"with neck outstretched, you fancy how." This was repeated eight or nine times, till at last a cock, thirty or forty yards away, appeared to notice the calling bird. He pricked up his neck, looked towards her for a short time, and then dived. At this she changed her whole demeanour. Up went her wings: back between them, with erected ruff and ears, went her head. A glance at fig. 7 will show her attitude. The wings were brought up, half-spread on either side of the body, with their anterior border pointing downwards. They were almost in the transverse plane, but sloped slightly backwards from the water.

In this position the beautiful white bar formed by the marginal wing-coverts, along the anterior margin of the wing, and the broad white blaze formed by the secondaries, which are quite invisible when the wings are closed, shone out vividly. The gap between the wings was filled by the head; this from the front somewhat resembled an old-fashioned picture of the sun, with the ruff rayed out considerably all round, and the ears were erected laterally so as to fit on to the top of the ruff on either side. Below the head shone the white of the puffed-out breast. The bird's whole appearance was wonderfully striking, and as unlike as possible to that of its everyday self.

All this took but an instant; directly the cock had dived she was in this attitude. As she waited for his re-appearance she turned eagerly from side to side, swinging nearly to the right-about and back again as if not to miss him. Eventually he came up, three or four feet on the far side, and facing away from her in the most amazing attitude. I could scarcely believe my eyes. He seemed to grow out of the water. First his head, the ruff nearly circular, the beak pointing down along the neck in a stiff and peculiar manner; then the neck, quite straight and vertical; then the body, straight and vertical too; until finally the whole bird, save for a few inches, was standing erect in the water, and reminding me of nothing so much as the hypnotized phantom of a rather slender Penguin.

As I say, it grew out of the water, and as it grew it gradually revolved on its long axis until at its fullest height it came to face the hen. Though all this was done with an unhurried and uniform motion, yet of course it took very little time. Then from his stiff, erect position he sank slowly on to the surface; the hen meanwhile put down her wings and raised her neck; and the pair settled down to a bout of the head-shaking. Their attitudes and actions were practically the same as those of the pair described above, but the bout only lasted about half as long. It was ended by the two birds ceasing to shake and gradually drifting apart. Finally they put down their crests and went off together to preen themselves and fish.

These actions, too, must now be named. I propose to call the attitude of the hen as she searched and called for her mate the *Dundreary-attitude*, for the two halves of the ruff in curtain-form give the bird, especially when seen from the front, a considerable resemblance to that famous personage of the drama. The attitude later assumed by the hen, with head back and wings arched, shall be the *Cat-attitude*, for the round ruff gives the bird the look of a very contented and somewhat fat cat. The cock's combined dive and emergence I shall call the *Ghost-dive*. The whole ceremony I have called the Discovery Ceremony (see p. 512).

(c) Now for the highest development of the courtship-actions that I have seen. The incident I am going to describe took place in the middle of the hour-and-a-half's watching the results of

which are recorded on p. 549. A pair of birds had been preening themselves and fishing, with occasional languid bouts of head-shaking. After a dive they came up not far apart and swam together with outstretched necks, which, as they neared each other, they gradually raised, beginning to shake their heads a little at the same time. The raising and the shaking progressed simultaneously, till when the birds were face to face they were in the regular "shaking" attitude and wagging their heads with a vengeance. The bout of shaking thus begun was the longest I ever saw: between them the birds shook their heads no less than 84 times, and with as much vigour at the eighty-fourth as at the first shake. There was rather a curious difference between the cock and the hen. At first neither of the birds did any of the wing-lifting, the strange parody of preening described above, and there named habit-preening. After the fifteenth shake, the hen began to give an occasional wing-lift, and these became more and more frequent on her part, until after about the sixtieth shake she was turning round and putting her beak under her wing-feathers between nearly every shake. The cock, on the other hand, did not begin this habit-preening until after the fortieth shake, and even after that only repeated the trick at rare intervals.

At the close of the bout, the pair swung parallel, but did not bring their necks down. Nor did they lower their ruffs; on the contrary, they put them up still further, from the pear-shaped form customary for shaking to the extreme elliptical, bringing down their ears meanwhile from the vertical to the lateral position, so that the whole crest now appeared like a large chestnut-and-black Elizabethan ruff. This change in the crests made me think something exciting was going to happen. Sure enough, the hen soon dived. The cock waited in the same attitude, motionless, for perhaps a quarter of a minute. Then he, too, dived. Another quarter of a minute passed. Then the hen appeared again, and a second or two later, some twenty-five yards away, the cock came up as well.

They were in a crouching position, with necks bent forward, ruffs still elliptical, and both were holding in their beaks a bunch of dark ribbony weed, which they must have pulled from the bottom. The hen looked about her eagerly when she first came up; when the cock appeared she put her head down still further and swam straight towards him at a good pace. He caught sight of her almost immediately too, and likewise lowering his head, made off to meet her. They did not slacken speed at all, and I wondered what would happen when they met. My wonder was justified: when about a yard apart they both sprang up from the water into an almost erect position, looking somewhat like the "ghostly Penguin" already described. *Sprang* is perhaps too strong a word; there was no actual leap, but a very quick rising-up of the birds. The whole process, however, was much quicker and more vigorous than the slow "growing out of the water" of the ghost-dive. In addition, the head was here not

bent down along the neck, but held slightly back, the beak horizontal, still holding the weed. Carrying on with the impetus of their motion, the two birds came actually to touch each other with their breasts. From the common fulcrum thus formed bodies and necks alike sloped slightly back—the birds would have fallen forwards had each not thus supported the other. Only the very tip of the body was in the water, and there I could see a great splashing, showing that the legs were hard at work. The appearance either bird presented to its mate had changed altogether in an instant of time. Before, they had been black and dark mottled brown : they saw each other now all brilliant white, with chestnut and black surrounding the face in a circle.

In this position they stayed for a few seconds rocking gently from side to side upon the point of their breasts ; it was an ecstatic motion, as if they were swaying to the music of a dance. Then, still rocking and still in contact, they settled very gradually down on to the surface of the water ; so gradually did they sink that I should think their legs must have been continuously working against their weight. All this time, too, they had been shaking their heads violently at frequent intervals, and after coming down from the erect attitude they ended the performance by what was simply an ordinary bout of rather excited shaking ; the only unusual thing about it was that the birds at the beginning were still, I think, actually touching each other. The weed by this time had all disappeared : what had happened to it was very hard to make out, but I believe that some of it was thrown away, and some of it eaten by the birds while settling down from the Penguin position.

In their final bout they shook about twenty times, getting less excited towards the end ; they eventually drifted apart, put their crests down, and almost at once began to pick food off the surface of the water.

Let us call the diving for water-weed and the appearing again with it in the bill the *weed-trick* ; and the rapid swimming together, with the subsequent figure erect breast-to-breast, let us call the *Penguin-dance*, for here once more the general resemblance to Penguins (exceptionally graceful ones, let us admit) forced itself upon the mind.

(d) One last scene before we pass from mere description to the heavier task of analysis.

Sitting on the bank one day, looking out over a broad belt of low flags and rushes which here took the place of the usual *Arundo*, I saw a Grebe come swimming steadily along parallel to the bank, bending its head forward a little with each stroke, as is the bird's way in all but very leisurely swimming. I happened to look further on in the direction in which it was going, and there, twenty or thirty yards ahead of it, I saw what I took to be a dead Grebe floating on the water. The body was rather humped up ; the neck was extended perfectly straight in the line of the

body, flat upon the surface of the water; the ruff and ears were depressed (fig. 8). So convinced was I that this was a dead bird that I at once began revolving plans for wading in and fetching it out directly the other bird should have passed it by. Meanwhile, I wanted to see whether the living would show any interest in the dead, and was therefore much interested to see the swimming bird swim up to the tail-end of the corpse and then a little way alongside of it, bending its head down a bit as if to examine the body. Then it came back to the tail-end, and then, to my extreme bewilderment, proceeded to scramble out of the water on to the said tail-end; there it stood for some seconds, in the customary and very ungraceful out-of-water attitude—the body nearly upright, leaning slightly forward, the neck arched back and down, with a snaky Cormorant-look about it, the ruff and ears depressed. Then it proceeded to waddle awkwardly along the body to the head end, slipping off thence into the water and gracefulness once more. Hardly had it done this when the supposed corpse lifted its head and neck, gave a sort of jump, and it, too, was swimming in the water by the other's side. It was now seen that the "corpse" had been resting its body on a half-made nest whose top was scarcely above the water, and it was this which had given it the curious hunched-up look. The two swam about together for a bit, but soon parted company without evincing any further particular interest in each other.

Both these birds had crests of very much the average size, so that it was hard to tell their sex; but I think that the "corpse" was a hen, the other bird a cock.

The meaning of this action (which I only saw this one time) remained extremely problematical to me while I was at the Reservoirs. The mystery will, however, be solved in the next section, and so let us anticipate and call the attitude of the "corpse" the *passive*, that of the bird that climbed on the "corpse's" back the *active pairing attitude*.

## 5. THE RELATIONS OF THE SEXES IN THE GREAT CRESTED GREBE.

### (i.) The Act of Pairing.

As I say, it was especially the proceeding last described which puzzled me; and it was not till I had got home and looked up the literature, that I found a welcome paper by Selous ('01)\* which exactly dovetailed into my own observations. I had been mainly concerned with the behaviour of the birds on the open water and during incubation; he had paid special attention to nest-building and pairing. His observations solve the mystery that has so far surrounded the Grebes' actual pairing; by them it is now established that the attitude which so puzzled me is adopted always, and only, for the purpose of coition, and that coition takes place solely on the nest. I should

\* A short summary of this paper will be found on p. 529.

perhaps have said "on a nest"; for the birds may build several incomplete nests or platforms before one, finally chosen to be the true nest, is finished and laid in.

From Selous's observations, the actions and ceremonies connected with coition are quite elaborate—almost of the same order of elaboration as the courtship-ceremonies, though the two rituals are completely independent and appear to have developed along quite different lines.

We have already got to know the *passive* and the *active pairing attitudes*. To complete the description of the mere attitudes, it remains to add that, before sinking down into the passive pairing attitude (which Selous calls "lying along the water"), the birds usually assume a curious fixed and rigid pose. I will quote Selous's words:—"... curling his neck over and down, with the bill pointing at the ground [weeds], perhaps six inches above it, he stood thus, fixed and rigid, for some moments (as though making a point) before sinking down and lying all along. There was no mistaking the entirely sexual character of this strange performance, the peculiar fixed rigidity full of import and expression."

We must now see how the *attitudes* are combined in the *actions* themselves.

In the first place, we have the *active pairing attitude* and the actions associated with it. These actions in pairing have been already once described, and they seem to show little variation. The bird leaps up, and comes down almost upright near the other's tail. Copulation is then attempted. Selous found it hard to decide if such an attempt was successful or not. When it seemed successful, the birds apparently uttered a louder cry than usual, and afterwards their behaviour had a satisfied look. Once, however, when the birds seemed thus satisfied, he adds: "The time occupied was extremely short, and one would hardly have thought from the position of the two birds that actual pairing had been possible." In other cases he could be fairly sure that the attempt was not successful. Whether successful or not, the act always ends in the peculiar way already described: the active bird waddles forwards along the other's body, and walks somehow over its head into the water, upon which the passive bird raises its neck, leaves the nest or platform, and swims away in normal position.

In the second place, we find that the *passive attitude* ("lying along") may take place either on the nest or platform itself, or else on the open water (but then apparently never far from the nest); the act of pairing itself, however, is possible only when the "passive" bird is lying on some firm support. In the second place, both cock and hen go into this attitude (the precise attitude which the lower bird assumes during the act of coition) indiscriminately: Selous's records give an approximately equal number of times for the two sexes.

However, before trying to draw any general conclusions, let us

take a particular case—that described by Selous on pp. 180–181 of his paper :—

About an hour earlier in the day there had been an attempt at pairing. Then, after a period of rest on the open water, the birds swam together towards the nest (which had been built the day before). When just outside the bed of reeds in which the nest was situated, the hen went into the passive attitude, on the open water. The cock came up to her, swam a few yards past her, went twice back to her and away again, then went right into the weeds and himself lay along the water in the passive attitude. While he was doing this (or immediately afterwards) the hen swam to the nest, leapt on to it, and sank down in the passive attitude once more. Upon this the cock came up to the nest, jumped on to the hen's back, and they apparently paired successfully, both birds meanwhile uttering a special shrill screaming cry.

Here are various points to be noticed. The *joint approach* of the birds to the neighbourhood of the nest is invariable when they have previously been some distance away. When one bird is sitting, or when both are already close to the nest, as when building is in progress, the case is of course different (p. 533); but in the period between nest-building and incubation they seem never to approach the nest singly.

The passive attitude on the open water close to the weeds and nest may or may not be assumed. In the three cases where this happened and Selous is absolutely sure of his facts, the bird that assumed this position was the female, and was also the leader in the procession towards the weeds. (We want to know more about this. It seems probable, from other considerations, that it is a mere coincidence for the leader to have been always the hen; but, this being granted, it is quite likely that the leading bird would be the more eager, and so would hasten to put itself into the attitude which apparently expresses readiness to pair.) In other cases the birds swam straight to the nest, and one of them ascended it and then went into the passive position.

Next, the way in which the cock swam about close to the hen while she was in the passive attitude, but still on the open water, "as though about to pair" (I quote Selous), is interesting. There must be a strong association established between the sight of the passive attitude and the desire to pair, so that the active bird shows its thoughts, so to speak, even when pairing is impossible (as when the passive bird is on the open water).

When the passive bird has gone into position on the nest, it is very nearly always the case that the active bird comes up to the passive one and examines it or swims about a bit, whether an attempt to pair is afterwards made (Selous, '01, pp. 180, 345) or not (*loc. cit.* pp. 165, 344, etc.). Sometimes the second bird is not eager, and refuses to come near at all (*e. g.*, *loc. cit.* pp. 172, 456). At other times (*loc. cit.* p. 341, and perhaps p. 181) an attempt

to pair is made, and the active bird jumps up apparently at once, without any delay. In the case observed by me the active bird seemed very definitely to examine the passive one, poking its beak down close to it; but the examination was very short, the attempt at pairing following immediately.

When the active bird is moderately eager but not quite eager enough to attempt to pair, it may swim up to the passive bird a number of times, each time make as if to spring up, and then decide not to, but swim away again.

The assumption of the passive attitude by one bird is generally, so far as I can see, used as an invitation to the other bird to pair: perhaps I should express myself rather differently, and say that it always denotes readiness to pair, and is generally used as a *primary excitant*—i. e., it is the first sign given by either of the birds of readiness to pair. This is well brought out by incidents such as this:—Both birds are building the nest; suddenly the hen jumps up on to the nest and goes into the passive attitude, every now and then raising her neck and looking round at the cock (Selous, *op. cit.*). At other times it may be only a *secondary excitant*—a mere symbol. This may happen when one bird is sitting and the other approaches the nest; the sitting bird may then assume the passive position at each approach of the other. Here the *approach* is the primary stimulus, and the assumption of the passive attitude is called forth by it, and not by internal causes. In this second case a less degree of “sexual feeling” is presumably needed to induce the passive attitude than in the first case.

But we are going too fast. We must not omit to notice the curious action of the cock in himself copying the hen's passive attitude. This action—one bird going into the passive attitude, the other coming up and examining it, and then going off and assuming the same attitude—appears only to occur when the first bird goes into position on the open water (and not on the nest), and even then not always. It seems, however, to happen in the majority of cases (though we are perforce generalizing from very few instances). It looks as if it were a signal to the first bird that the second was ready and willing to proceed further in the matter; for the birds after this may proceed together to the nest, where the first (*loc. cit.* p. 180) or the second (*ibid.* p. 456) bird ascends the nest and assumes the passive attitude once more. In other cases, however (*ibid.* pp. 179, 454), the affair ended with the second bird's assumption of the attitude. Here it looks as if a ritual ceremony was developing out of a useful action (see below).

As regards the actual act of pairing (or its attempt, which for our present purpose comes to the same thing), *the two sexes seem here also to play interchangeable roles*. In 1900 Selous saw three attempts to pair, one apparently successful, two unsuccessful: in all three cases the active bird was the larger of the pair. In 1901 he saw two attempts, both of which he thinks were

successful: here the active bird was in both cases the smaller of the pair.

Now, if we could be sure that the 1901 pair was the same that was there in 1900, all would be well: but we cannot be sure. There was a marked difference in the pairing-behaviour of the 1900 and 1901 pairs—a difference that cannot be referred back to the fact that in 1900 the birds were building a true nest and were incubating, while in 1901 they had only got to the length of building a pairing-platform. In 1900 the smaller bird (that we have so far presumed to be the hen) was more forward in invitation, while the active pairing-position was adopted by the larger bird alone; in 1901 the case was exactly reversed. It would be, in my opinion, more remarkable that such a change of character should take place in two birds in the space of one year than that the same water should be occupied by two different pairs—albeit but a single one—in two successive years. Mr. Selous, however, writes to me that for various reasons (*e. g.*, the site of the nest, etc.) he is practically convinced that the birds were the same in both years. However, whether the pair was the same pair or not, in both years there was a marked difference in size both of body and crest between the two birds of the pair, and, if all the books are not wrong, this should be quite enough to distinguish the sexes. Sometimes, it is true, the two birds of a pair are almost exactly alike; but nowhere do I find it stated that the hen is ever larger or has a better crest than the cock. It is the part of the professional ornithologist to find out if this is ever so; till then, we must be content to say that it is extremely probable that either cock or hen can play the “active” part in copulation—what we should usually call the male part. This can be more easily imagined in birds than in almost any other animals in which copulation takes place, but even in a bird is remarkable enough. Definite attitudes of the two participating organisms have been evolved to facilitate the passage of genital products in a definite direction: and here, hey presto! although the genital products continue to pass in the same direction, yet the attitudes, developed only in relation with and accessory to this direction, are at will reversed.

This facultative reversal of pairing-position would certainly be remarkable; but even for the moment supposing that it does *not* occur in our Grebe, it would merely appear as the as yet unattained end of a process of sex-equalization which in this species has already run a considerable course. This process consists in a gradual transference of all the secondary sexual characters of the male to the female, and *vice versa*. In its general aspect it will be discussed later; here it will be sufficient to consider it in relation to the pairing actions alone.

Let us see what is without doubt common to both sexes in the Crested Grebe to-day. First of all, we find that either cock or hen may lead the way towards the pairing-platform. Secondly, either cock or hen may assume the passive pairing-position (the

position that one would naturally call *female*) on the open water. Thirdly, either cock or hen may assume this position on the nest or pairing-platform. This is important, for the pairing-platform is never ascended except for the purpose of pairing, or for this position, which we may call the beginning of, or the invitation to, pairing, and the nest only ascended for these two purposes and for incubation. Fourthly, when one bird is in the passive position, the other, be it cock or hen, may come up to it, examine it, and make as if to leap up on to it, just as it often does before an actual attempt at pairing is made. The natural end of this sequence would be that, fifthly, either cock or hen might not only make as if to ascend into the active position, but actually do so. If the text-books are right in their descriptions of the sexes in the species, then we can say that this end has been reached, and that, as far as pairing-positions go, the sexes are interchangeable. If the text-books are wrong, then our evidence is simply insufficient. Here it can only be shown that, however incredible this reversal may appear, yet it is quite certain that in the Great Crested Grebe all the preliminary steps towards it have been already taken.

Further, Selous (*loc. cit.*) places on record some remarkable facts which show that reversal of pairing-attitude does take place in tame Pigeons. Here he several times saw, immediately after the act of pairing, the "male" bird crouch, and the "female" then get into the normal male attitude. The act of pairing was then gone through a second time, but with the attitudes of the birds reversed. See also Selous '02.

We have therefore evidence that the full reversal can take place, and now only want to be certain that it has taken place in this species. In any case we can say that characters (in this case *attitudes* and *actions* only) of the female have been transferred to the male, as well as characters of the male to the female.

We must now go on to consider a very different question, which is also well brought out in the pairing-habits of the Great Crested Grebe: I mean the gradual change of a useful action into a symbol and then into a ritual: or, in other words, the change by which the same act which first subserved a definite purpose directly comes later to subserve it only indirectly (symbolically), and then not at all. The action in question here is the passive pairing-attitude, and the Grebe is interesting as showing all three stages of the process at one time—the passive attitude employed sometimes directly, sometimes symbolically, and sometimes ritually. Speaking phylogenetically, we have the following steps:—

- (1) The ascent on to a nest or platform, and the assumption of the passive attitude, are necessary if pairing is to take place, and the passive bird must get into position before the active bird can even begin its part in the coition act.

- (2) The ascent and the attitude are used by the passive bird as

an incentive to the active bird, as a sign of readiness to pair. The active bird may or may not respond.

(3) As a symbol, the *attitude* is obviously more important than the actual ascent on to the nest, since the attitude is used only in pairing, while the birds may ascend the nest for various purposes; and, in addition, the assumption of the attitude comes after the ascent, and is thus in time more immediately associated with the act of pairing. Thus the attitude by itself comes to be used on the open water (though always close to the nest) as a sign of readiness to pair. We may say that readiness to pair is indicated precociously—it is pushed back a step. Such processes of pushing back are very common in early ontogeny; embryologists then say that the time of appearance of the character is *caenogenetic* (even though the character itself, as here, may be *palingenetic*). The phylogenetic change has here been precisely similar; the only difference is that the displacement affects a mature instead of a very early period of life.

(4) The attitude being now sometimes a mere symbol can be, and is, employed by either the active or the passive bird. In fact, when one bird employs it thus symbolically, the other usually responds by immediately repeating this symbolic use.

(5) From useful symbolism to mere ritual is the last step—one that has taken place often enough in various human affairs. It appears that these actions and attitudes, once symbolic of certain states of mind and leading up to certain definite ends, lose their active symbolism and become ends in themselves. When I say that they lose their active symbolism, I mean that they are now not so much associated with readiness to pair as with the vague idea of pairing in general. Thus associated with pleasurable and exciting emotions, they may become the channels through which these emotions can express themselves, and so change from purposeful stimuli to further action into merely pleasurable self-exhausting processes (see below). It is at least hard to see how to explain such happenings as that described on p. 534, (c) 6, where first one bird and then the other goes into the passive position on the open water, after which there is simply a resumption of feeding or preening.

Another general point worth noticing is this:—In the case of this Grebe the male has even less possibility of enforcing his desires than the majority of birds. In a few birds the male is not so helpless. The ordinary Barndoor Cock, for instance, is often rather forcible in his methods. In the Wild Duck (*Anas boschas* L.) the drakes often kill the ducks by continued treading\*. Somewhat similar forcible pairing is recorded of the Mute Swan (*Cygnus olor*). In such species it is by no means necessary for the race that the act of pairing should be particularly pleasant to the female. In most birds, however, the female has the upper hand: she can always prevent the cock

\* Huxley, Biol. Centralbl. 1912.

from pairing with her, by simply running or flying away (*cf.* the Redshank, Huxley, '12<sub>1</sub>). In our Grebe we are a step further still: not only must the female (or the passive bird, if we want to be precise; but this is, for the present, complicating the issue unnecessarily) be willing to pair, but she must also take the first steps—must ascend a nest or platform and assume a special position—before the cock can think of pairing. Here, therefore, supposing that the functions of the sexes had not been almost equally distributed, it would have been necessary for the hen to have had a strong impulse towards pairing: it might be that she was impelled directly by a violent physiological stimulus, or more indirectly by association, through the act being extremely pleasurable.

The phylogenetic course of events is hard to disentangle; we might suppose it to have been somewhat as follows:—

(1) Owing to the need of a firm support for pairing, it became necessary, as above set forth, for the female to take the initiative in the act of pairing, by assuming a special position.

(2) The male had thus no means of expressing his readiness to pair [whereas in most monogamous birds it is the male, as one would expect, who takes the initiative: *cf.* the Warblers (Howard, '13), the Redshank (Huxley, '12<sub>1</sub>), etc.].

(3) Meanwhile, quite independently, a process, or tendency—call it what you will—had shown itself, by which the characters of one sex might be or tended to be transferred to the other, and *vice versa*.

(4) This was seized upon by Selection (we cannot as yet speak less metaphorically) and employed to supply the present want; the pairing attitude of the female was transferred to the male to give him, too, a means of expressing his readiness to pair—to enable him, should he wish it, as well as the hen, to take the first step towards the performance of the act of copulation by the pair.

(5) As so often occurs, the process did not stop precisely at the desired spot (we still speak in metaphors, for brevity's sake); with the female pairing-attitude was transferred the female pairing-instinct, and so came about the complete or nearly complete facultative reversal of the pairing habits.

This naturally does not pretend to be more than a possible scheme; but it is worth while setting out such a scheme, merely to show how this "reversal of the sexes" could have come about.

## (ii.) Courtship.

I have started with the subject of coition, because the first thing I want to make clear about the courtship-actions is their total lack of connection with the act of pairing itself—a notable fact, in which the Grebe differs radically, of course, from many other birds, especially those in which the sexes differ in appearance, *e.g.* the Bustard or the Peacock, but also some in which the sexes look alike, *e.g.* the Redshank.

In relation to this, no doubt, is the fact that pairing only takes place on the nest, and that the nest is hidden away among the reeds, while the courtship actions are, I believe, always gone through out on the open water. This, in itself, would not be conclusive evidence of total separation of the two sets of actions, for the performance out in the open might be followed directly by a return to the reeds and subsequent pairing. But there are two further facts which make it conclusive. In the first place, one of the reservoirs at Tring is completely bare of reeds, and consequently of Grebes' nests too. It is, however, the richest in fish, and numbers of Grebes fly over to it from the other reservoirs every day, and at all hours of the day, to feed. Now, in spite of the absence of reeds, and so of nests, and so of the possibility of pairing, the birds interrupt their fishing, or sleeping, or preening, to go through the ritual of courtship just as often on this reservoir as on any of the others. That is point number one.

Point number two goes still further.

I frequently kept individual pairs under observation for a considerable length of time, and then, if I watched long enough, always found that one set of courtship-activities would in point of fact be followed by a pretty long interval of resting or fishing, and that then this time spent in every-day affairs would be again succeeded by another series of courtship-actions—a proof that these actions are what we may call *self-exhausting* and not *excitatory*. The best record, because the longest, was on this same reedless reservoir. I had one pair under observation for an hour and forty minutes (section 10, record 11). During that time they had six simple bouts of shaking, and also two prodigious long bouts, followed each time by the diving for weed and then the strange Penguin-dance. And between all these elaborate displays of sexual emotion, no sign (or possibility) of pairing—nothing but swimming, resting, preening, and feeding.

I was thus—much against my preconceived ideas—driven to think of all the complicated postures and evolutions of courtship in the Grebes as being merely *an expression of emotion*.

The particular form of expression used is no doubt determined—predetermined—by the arrangement and innervation of certain structures which the birds possess: but the impulse to use the muscles and nerves is an emotional one—during courtship there must be in the mind of the bird an excitement, a definite feeling of emotion. Let us, to satisfy the physiologists, try to put it in terms of nerve-currents. One member of a pair is continually seeing its mate at its side. This, in its present physiological condition, stimulates certain tracts of its brain, charging them up and up until they are in a state of considerable tension (mental accompaniment:—state of diffused emotional excitement). Finally, the tension reaches the critical point, and a discharge follows. This discharge flows down hereditarily-determined paths, and actuates the muscles concerned in courtship (mental accompaniment:—violent and special emotion, quickly dissipating

itself with a sense of "something accomplished, something done.")

This merely indicates the possible material mechanism; of the actual, we know next to nothing. However, by comparing the actions of the birds with our own in circumstances as similar as possible, we can deduce the bird's emotions with much more probability of accuracy than we can possibly have about their nervous processes: that is to say, we can interpret the facts psychologically better than we can physiologically. I shall therefore (without begging any questions whatever) interpret processes of cause and effect in terms of mind whenever it suits my purpose so to do—which, as I just said, will be more often than not.

Let us take the parallel from human affairs. Far be it from me to go into the matter with a heavy hand; let us merely look at a few familiar facts in an unfamiliar biological light. The "courtship-actions" of man are mostly predetermined by heredity: any young couple that you like to take will be pretty certain to "express their emotion" by holding each other's hands, by putting their arms round each other's waists, or by kissing each other; and of this last action kissing on the mouth is the "highest development." Let us merely notice that these actions are not perhaps exactly parallel with what we find in the Grebe—that they are altogether more fluid, less fixed, and that they are sometimes less self-exhausting and more excitatory in character: on the whole, however, they are not very different. Moreover, in their case we know a great deal about the accompanying emotions, either from our own experience or from what others tell us. To take only the most specialized form of human courtship-actions, the kiss; although we know that it may act as an excitant (*cf.* Dante's famous lines on Paola and Francesca) yet the accompanying emotion is in itself quite special, different from all others, and the emotional process is usually something *an und für sich*, expressing itself in the action, and exhausting itself in the process with a feeling of inevitability. In the memory, however, it leaves its trace, and as it were desires to repeat itself, but only when the emotional tension shall again have risen (think of Plato's epigram to Agathon: or the lovers in Richard Feverel; or Romeo and Juliet). That will suffice to show what I mean by a self-exhausting expression of emotion. Such a process would be one that to the doer of it feels at the time almost inevitable, though he can only do it at certain moments. At other times, determined by his general mental state (*cf.* section 10, record 1), the action, however pleasant to recollection, is not "spontaneously" possible, and if performed is forced or at least not fully pleasurable. When normally executed, the action is accompanied by violent and pleasurable emotion, which usually dies down, or changes, into a quite different feeling, one of satisfaction, meanwhile leaving its mark in the memory. Its recollection then acts as a partial stimulus, so that next time it is a little more easily performed.

This will, in the first place, show how difficult, and almost inevitably futile, it is to try and deal with the emotional essence of things by the methods of "ordinary biology"; I think, however, that it will serve to explain what I mean by a self-exhausting expression of emotion, and will give the point of view from which to look at the facts of the Grebe's courtship: let us now go on to examine the facts themselves more systematically. I will take the different forms of courtship-action one by one, describe their usual occurrence and their relation to other actions, and then mention the most important variations or exceptions that I have seen.

The various attitudes already described are combined into definite *actions* or *ceremonies*.

(a) The simplest form of courtship-action is the *bout of shaking*, of which I have described a typical example. As already seen, shaking may take place either before or after other courtship-actions, but in perhaps the majority of cases it is not thus a link in a chain of processes, but a single self-originating and self-exhausting process. It varies a certain amount in intensity and in length, and also in the amount of habit-preening that takes place. Of this there may be none, or, towards the end of a bout, there may sometimes be more preens than shakes. The bouts seem, to the casual onlooker, to start themselves—in reality, I think, each bird excites the other. One gently shakes its head under the force of rising emotional tension; the other bird had not quite got to that stage, but the sight of its mate shaking acts as a stimulus, and it too pricks up its head a little and gives a shake. This reacts on the first bird, and so the excitement is mutually increased and the process fulfils itself—a very good example of "crowd-psychology," and also a good example of an epigenetic process\*.

There is one well-marked variation of this form of courtship which seems to denote a higher level of excitement; it is especially common when a third bird has intruded into the domestic harmony of the pair and has been driven off (section 5, iv.).

Here the beaks are pointed somewhat downwards, the neck brought a little forward instead of vertical, the whole head brought forward and curved over, and the ruff erected more than usual (fig. 6). This attitude is almost always confined to the beginning of a bout, the birds sooner or later relapsing into the ordinary position.

The bout of shaking is not only the commonest form of courtship-action, but it also forms part of all the other more elaborate forms. It always ends the series of actions, and often begins them as well. It is as it were the foundation on which they are built, and was probably (if I may express a mere opinion) the earliest to appear in phylogeny.

The other ceremonies of courtship are all formed by the

\* See also p. 544, where one bird won't shake, and the other wants to.

combination, in various arrangements, of the shaking-bout, the Dundreary, the Cat, the Ghost-dive, the weed-trick, and the Penguin-dance; in addition, they may be slightly modified by jealousy.

They can be divided into two groups: (1) those in which the Cat-position plays a prominent part, and (2) those into which weed-carrying enters. Let us consider them in this order.

The Cat-position forms a part of two quite distinct ceremonies, which, simply for the sake of ready reference, I shall call the *Ceremony of Discovery* and the *Display*. The first of these is gone through, as far as I can make out, when the two birds of a pair find and rejoin each other after being separated for some time. The second always occurs in the middle of a bout of shaking; on such occasions I presume that the shaking has not been "self-exhausting," but that the emotional excitement that accompanies it has reached a slightly higher level than usual, with the result that it overflows into a new nervous channel, and so expresses itself in this new way.

(b) *The Ceremony of Discovery*.—A typical case has already been described (p. 497). I should interpret the facts thus:—The two birds of a pair have become separated—perhaps they have gone off fishing in different directions, or one has been on the nest and the other has not stayed near by. They wish to rejoin each other. To this end the bird that is searching puts itself into a special attitude, which is probably adapted for uttering the special cry only heard on such occasions, and cruises about, alternating its signal-calls with moments of looking about it. On hearing the call, several neighbouring birds will usually prick up their necks and look about them; but I believe that it is usually only the searching bird's true mate who takes any further interest (this would doubtless depend on the emotional state of the neighbouring birds). Once this discovery of the missing mate has been made, a special ceremony takes place to celebrate the event. This ceremony is a peculiar one, and is practically confined to these occasions of discovery; very possibly the memory of the ceremony and its excitement adds to the eagerness felt by one bird of a pair to rejoin the other. The ceremony itself usually consists in this—the bird has been discovered dives, upon which the searcher puts itself into what I have called the Cat-attitude, a bizarre but beautiful position obviously recalling the elaborate displays of many other birds. In this attitude the searcher waits, almost always in a state of great excitement, as shown by its turning itself hither and thither, from side to side. It is stimulated to this excitement by the diving bird: first of all, as the dive is very shallow, the diver's approach is marked by a swift ripple of the surface; and then, when the diver at length appears, it is in a shape as unlike that of everyday life as is the "Cat-position" of the searcher—albeit the two are at opposite poles of the Grebe's capabilities. Sometimes the diver emerges when only

a few feet from the searcher. This is merely to reconnoitre his position; head and neck alone appear, the crest not erected, and are swiftly withdrawn again. The final appearance takes place almost always beyond the searcher, and the bird emerges with its back to the other, facing it only as, revolving on its axis, it settles down. The performance always ends with a bout of shaking.

Although in my "typical" cases the searcher has always been the female, yet the male may also search for his mate in the same way. I have watched an obvious cock in the regular Dundreary (search) attitude for a long time; only on this occasion no mate responded to the call. Further watching is necessary to see whether it is merely an accident that my searchers have usually been hens, or whether my observations represent reality. (It may possibly be connected with the fact that the hens seem to spend more time on the nest than the cocks; but this is mere conjecture.)

(c) *The Display Ceremony* is quite different. The birds are already together, and the display is simply a form of excitement similar to the bouts of shaking. In typical cases the pair will be indulging in a bout of shaking; suddenly one of them flies off a few yards and puts itself into the full Cat-position, showing its circular ruff and white-striped wings to its mate. There is no diving, however, and, after some seconds' display, the birds swim together and there is another bout of shaking; after this they simply swim off, or separate, or feed. Either cock or hen may go into the Cat-attitude. In one case the first bout of shaking had been preceded by a "flirtation" (p. 521) on the part of the cock.

To show how one ceremony may blend into another, I adduce the following instance:—There was a regular Discovery Ceremony, the hen calling to the cock, but with this difference, that they swam together, shook, and the hen flapped off and went into the Cat-position, and that only then did the cock remember, so to speak, to do the ghost-dive (p. 498). Another mixed "ceremony," this time more closely related to pure display, is related on p. 547.

(d) Finally comes the ceremony of the *Penguin-dance*. I have little to add to the description already given (p. 499). Twice, curiously enough, a single pair was seen to perform the dance twice in a morning. This might imply that some special physiological state, probably of high excitement, was necessary for the act, for I only saw it on two other occasions, and Selous only saw it once.

The performance can only be gone through when both are equally excited; for instance, once (p. 547) after a bout of shaking the cock dived and fetched weed from the bottom. The hen, however, was not stimulated to do so too, and when he came up he found no answering stimulus, and so dropped the weed as he swam towards his mate.

There is no reason for supposing even this elaborate ceremony to have any direct relation whatever with coition. It is a form

of excitement and enjoyment, seemingly as thrilling to the birds as it is to the watcher, but, like all the other courtship-actions, self-exhausting.

Very interesting "incomplete stages in development" of this ceremony were seen in one pair of birds, ranging from simple diving to the complete ceremony (see below).

(e) *Other Courtship Ceremonies.*

(1) *Back-to-back Ceremony.*

There are considerable individual variations in the courtship-activities of the Grebe, and I have seen occurrences which may well be interpreted as rudiments of new ceremonies. In one pair, for instance (section 10, record 12), the birds almost always went into a formal back to back, or rather tail to tail, attitude after each bout of shaking.

(2) *Diving Ceremony.*

Other actions seem to stand in some relation to the more highly-developed ceremonies. For instance (pp. 545, 552), simple diving, either by one or both birds, without any fetching of weed from the bottom, is introduced as part of the courtship between the two bouts of shaking.

(3) *Weed-trick Ceremony.*

In still other cases, the weed-trick is gone through and is followed immediately by a bout of shaking. In both pairs in which this was seen, one bird alone brought weed, although in one pair (not in the other) both had previously dived. I am inclined to believe (but more observations are needed) that two distinct ceremonies are here involved: first, the fetching and offering of weed by one bird, usually the cock, to its mate; and, secondly, a typically "mutual" ceremony involving simultaneous diving of both birds of a pair: and on to this latter the "penguin dance" has been grafted.

The offering of weed is strongly reminiscent of occurrences in the sex-differentiated, non-mutual courtships of other birds, such as the Warblers, where the cock often carries leaves or twigs in his mouth during sexual ecstasy (Howard). It seems to me probable that, since diving is necessary for weed-fetching, the one has come to be associated with the other, and the two ceremonies have come to be mixed up: in the extreme case on one side there is no mutual ceremony—only an offering of weed by one bird to the other; at the other extreme we have the complete penguin dance as described on p. 499, where both cock and hen bring up weed; and as intermediates we have mutual diving (p. 552) and mutual diving where the cock alone brings up weed (p. 552, end).

Taken all in all, the courtship is chiefly *mutual* and *self-exhausting*: the *excitatory*, *secondary-sexual* forms of courtship such as weed-offering or pure display serve not as excitants to

coition, as in most birds, but as excitants to some further act of courtship; and this is always a mutual and also a self-exhausting one. The excitants to coition are of a very special nature, and are symbols, rather than mere general excitants.

*Habit-Preening.* (See p. 497.)

This is very frequent, occurring in about half the bouts of shaking seen. The more excitement, the less preening, seems to be the rule; long bouts may sometimes degenerate into practically undiluted preening, the head simply being brought more or less up, but not shaken, between the "preens." It is always the hind end of the wings, I believe, which is raised and let fall by the beak.

In some way there must be a strong association between preening and head-shaking in the Grebe, for solitary birds who were really preening themselves I have several times seen raise their heads, slightly bristle their crests, and give a rudimentary shake. Why or how the association has taken place is more difficult to say. I certainly believe that the action I call habit-preening has been derived from true preening, and has been ceremonialized in the process of becoming part of a courtship-action. For the present we must leave it at that.

*"Habit-Shaking."*

That for some reason there is a very real association between shaking and preening is shown by the following facts. When actively engaged in real preening of themselves, the birds are often seen to lift their heads, give a rudimentary shake or two (without erecting ears or ruff) and then go back to business. This is generally seen when the bird is engaged in preening its hinder parts. We have observed it in autumn as well as in spring, and so it presumably takes place the year round; there is thus obviously a real association between the preening and the shaking, and the shaking is not a mere release of simpler sexual energy.

This is exactly the converse of what I have called "habit-preening," and may therefore appropriately be styled "habit-shaking."

There is thus a single association with a two-fold result. How it can possibly have arisen, or what purpose it can serve, remains to me at present an absolute mystery. I leave it as a puzzle to future bird-watchers and comparative psychologists.

*Fighting between Cocks.*

I saw very little of this beyond mere hostile expression (p. 521). Once, however, I saw two birds actually grappling: one was struggling half-submerged, while the other was more or less on top of it, and had hold of the feathers of the back of its opponent's head. After some considerable splashing and struggling, they separated and swam apart.

In birds which pair up early and remain "married" for the season, like the Grebe, one would, of course, not expect to find any of the regular combats seen in other species. It would be interesting to see whether there is more fighting in February, during the actual process of pairing-up.

The question must now be put—"What for?" What is the good of all these divings and posturings, these actions of courtship, these "expressions of emotion"? To what end are colours and structures developed solely to be used in them, and what return is got for the time and energy spent in carrying them out? They are common to both sexes, and so have nothing to do with any form of true sexual selection; they are self-exhausting processes, not leading up to or connected with coition, and so cannot be sexual excitants in the ordinary sense of the term.

It must be, however, that they fulfil some function; and I believe I know what this function is. I believe that the courtship ceremonies serve to keep the two birds of a pair together, and to keep them constant to each other.

The Great Crested Grebe is a species in which the two sexes play nearly equal parts in all activities concerned with the family. The cock shares equally in nest-building, nearly equally in incubation and early care of the young (it is only later that the young pass into the care of a single parent, probably the female, see Pycraft, '11). Thus, from the point of view of the species, it is obviously of importance that there should be a form of "marriage"—a constancy, at least for the season—between the members of a pair. The same result—marriage—is observable in such a species as man; but in man the main cause is a division of labour between male and female, whereas in the Grebe the sexes have been made as similar as possible. It would seem that the Grebes' family affairs had simply required more labour to be spent on them, and that Evolution had happened to go along the simple path of increasing the quantity of labour, by bringing the male in to do female's work, instead of improving the quality by adopting the principle of specialization.

Birds have obviously got to a pitch where their psychological states play an important part in their lives. Thus, if a method is to be devised for keeping two birds together, provision will have to be made for an interplay of consciousness or emotion between them. It would be biologically enough if they could both quite blindly, and separately, attend to the common object—nest, eggs, or young; but with brains like theirs there is bound to be a considerable amount of mental action and reaction between them. All birds express their feelings partly by voice, and very largely by motions of neck, wings, and tail; and not only this, but the expression can be, and is, employed as a form of language. This being so, we have here a basis on which can be reared various emotional methods of keeping birds of a pair together. As always, selection of accidental variations has led to very diverse results; so that we see this "emotional companionship" playing a

part in many apparently very different actions of birds. Herring-Gulls sit or stand close beside each other for hours together, occasionally rousing themselves to a joint ceremony of shaking their necks. As the Snipe drums overhead, there is often a call from the marsh below. Many birds when paired are always calling to each other, and probably singing birds sing partly to their mate; Dabchicks have a special spring note, usually given as a duet. As a very simple case, I have seen a pair of Blue Tits very recently paired up who, although feeding, were perpetually calling to each other and at frequent intervals coming close up side by side; it was perfectly obvious that they simply took pleasure in each other's presence, like the engaged couple that they were.

We have thus the following train of reasoning. Many birds must be kept in pairs during the breeding-season. This may be partly effected by the instincts of the separate birds—the instinct to build a nest, to sit on eggs, to feed young; and partly by instincts which only can find play when the two birds are together. These latter are often very emotional, and the courtship habits of the Grebe afford a very specialized example of this emotional bond between members of a pair.

If my contention is correct, it is clear that many actions and structures solely used in courtship are of use to the species, and not only to one sex of the species; these therefore must be maintained by Natural as opposed to Sexual Selection.

### (iii.) Nest-building.

I rely almost entirely on the observations of Selous ('01, and see my Summary, section 8).

*Materials.*—Selous' nest was made mainly of dark ribbony weed, fetched from the bottom. Some surface-weed was also used. Besides this, such objects as water-lily stalks and large water-logged sticks are occasionally employed, the latter seeming to help anchor the nest. To steady the nest still further, the weeds are often woven among the stems of growing water-plants. As with other birds, the materials vary with the situation. In *Arundo*-beds the nest is very largely made of bits of reed-stem, though always with some weed; while elsewhere no reed is used at all.

*Time, etc.*—The main bulk of the nest appears to be built very quickly—in a few hours, in fact. This main portion is always built in the early morning (as with many other birds), and while on one day there may be no nest to be seen, by the next it may be nearly completed. In this very active building both cock and hen often take part simultaneously; they work very hard, averaging between them more than two cargoes of weed every minute, and going on for half an hour or an hour at a time without stopping.

After one nest has been built, another may be started (and

nearly finished) next day at no great distance. In the case noted by Selous, during the building of each nest the cock built himself a platform or rudimentary nest close to the bank and not far from the nest that was in progress. In the construction of this the hen did not share.

#### FUNCTIONS OF NEST.

There seem to be at least three kinds of nests—the true nests, the pairing platforms, and the cock's platforms.

(1) The true nests are bulky structures, rising well out of the water. A single pair of birds may build more than one. In one of these the eggs are finally laid. It is not known whether a pair always build more than one (probably not), nor whether, if more than one is built, it is always the last that is chosen to receive the eggs.

(2) The pairing platform (one seen by Selous and one by me) is a sodden, messy-looking structure, apparently much trodden down, and practically flush with the surface of the water. It seems to be used only as affording the necessary support for the action of pairing, and is apparently built some time before the true nest, *e. g.* Selous ('01, p. 339 *et seqq*) watched a pair for three weeks and saw no nest except a single platform, which was used exclusively for pairing (and pairing actions). It is distinctly improbable (from the appearance of all true nests that I have examined) that such a platform would be built up and turned into a true nest, though no evidence on this point is forthcoming.

What is certain, however, is that pairing need not always take place on such a platform, since Selous saw it occur on a true nest, and one which had probably one egg already in it. It appears to me likely that such platforms are built early in the season, when only copulation (or the preliminaries thereto), and not incubation, is in progress. Then, later, true nests are necessary to lay the eggs in, and once these are built copulation can take place in them just as well as on the platforms—*i. e.* the platforms are only temporary expedients, rendered necessary by the birds' pairing habits, and would thus phylogenetically appear to be degenerate nests.

(3) The platforms of the cock. These, too, are imperfect structures, and are probably also degenerate nests. In the case observed by Selous they were built close to the bank by the cock alone, during the construction of a true nest close by. When built, they were used (by the cock alone) as resting-places where he sat or, more frequently, stood.

Their true purpose is hard to see. It cannot be that the cock needs a resting-place more than the hen (unless—merely to state a case!—we suppose that in the month of May both sexes need

to rest on some firm support more than at other times, and that the hen incubates more than the cock, so that he has to build himself an extra resting-place). Possibly such platforms have something to do with receiving the young after hatching, and are built precociously. But this is mere guesswork—further watching must reveal their secret. Mr. Selous, in a letter to me, says he thinks now that the platform is due to an aberration of the nest-building instinct in the male. From Selous' own records, however, it is clear that the male certainly uses it to rest on.

*Differences in building of the different kinds of nest.*

The bulk of the true nest is built by both birds together in a very short time. After that, it seems to be casually added to during the time of incubation. This is useful, for the nest would otherwise get gradually pressed down into the water. It also tends to lose its slightly cupped form, and to remedy this the sitting bird may often be seen to pick bits of weed from the inside or the outside of the nest and lay them on the rim.

The cargoes of weed brought during incubation are often very small compared with those brought during the first building of the nest, and the whole action seems often to have rather the stamp of a habit about it—"I am going to the nest, so perhaps I had better bring a weed or two along."

During the main building, one bird sometimes sits on the nest for a short time; during this period one bird might also lie along the nest in the passive pairing position, as an invitation to the other to pair. But apparently pairing and pairing-actions are gone through more often when the bulk of the nest is finished, or when a platform alone exists—nest-construction thus appearing to use up most of the emotional energy of the birds.

*The cock's platform.*—It would be interesting to know if this is always made during the construction of the main nest, or if sometimes the cock set about it in cold blood, before or after the true nest was finished. It is quite possible that the cock and the hen stimulate each other to active nest-building as they do to courtship activities (p. 511), and that while they are in this excited state, and only then, some of the nest-building energy is, in the cock, diverted to his platform.

*The pairing platform.*—This (only one recorded case) was already built when Selous first noticed it. Only small pieces of weed were added to it, and usually "in a very perfunctory manner" (Selous, '01, p. 342). After one bird had unsuccessfully invited the other to pair, it often "manipulated the weeds a little with its bill" before coming off the platform.

We thus badly want to know about the building of the pairing platform; and also whether, during its construction, the cock builds a platform for himself, as he does during the building of the true nest.

*Share of the sexes in nest-building.*

The only data are based on the actions of a single pair—that observed by Selous in 1900; we must not, therefore, generalize too far. However, certain things emerge clearly. Both sexes work vigorously at the nest. During nest-building, the cock builds a platform by and for himself not far from the nest. In this particular pair the cock seemed slightly more active in nest-building, though the hen was more skilful. This may be, and probably is, merely an individual trait. As far as the building of the true nest goes, both sexes seem to be at least as similar as they are, for example, in appearance and in courtship habits. The mysterious platforms of the cock remain as one of the few truly secondary sexual characters of the species.

*Psychology.*

It seems probable that the same sort of psychological mechanism holds here as in courtship. Fetching weeds from the bottom and piling them in a heap is an instinctive act affording pleasure or relief. Although it is much easier to imagine a bird deriving pleasure from solitary nest-building than from solitary courtship action, yet here, too, it seems as if the cock and hen are mutually stimulated to activity. This is, at all events, an eminently useful trait, for it ensures that the nest shall be quickly built, that the pair shall keep together, that they shall build one nest at a time (instead of two, perhaps widely separated ones), and so forth.

That it is pleasurable may be further inferred from the fact that when the fever is upon them the birds may build two large nests in two successive days (Selous, *loc. cit.*). This may seem wasteful, but here, as in so much else, Nature indulges in a considerable reserve—better too much than too little. This is the case with reserves of food, our own appetites, the number of times which most animals pair, the number of unpaired males in polygamous species and in Bees, etc., etc. Here, perhaps, the reserve is indirect rather than direct; it may not even be any advantage to have built two nests instead of one, but it may well be an advantage to have such a strong nest-building instinct that two or more nests happen to result, instead of one.

Finally, again, as in the courtship, association plays its part. What has once been done with pleasure, is done again easily as a habit. So when a bird is near the finished nest, and especially when the birds are there together, weeds are often added, but almost always in a more or less perfunctory way.

Why, after one bird has unsuccessfully invited its mate to pair on the platform, it should often dive and bring weed to the platform, I do not fully see. We can only say that diving and weed

are connected by separate and perhaps roundabout mental paths with nest-building, courtship, and pairing; and that what we know is only an outline of the birds' behaviour.

(iv.) Relations of different pairs to each other.

(Fuller details are given in Part II.)

The Great Crested Grebe, as we have already seen, pairs up very early in the season. What is the relation of the pairs of birds to one another?

As a general rule, the two birds of a pair seem to take very little notice of the rest of their species. Occasionally, however, there is some contact. There may be jealousy on the part of one bird, and this jealousy may, in any particular case, be merely precautionary, or actually justified by flirtatious behaviour on the part of the other bird of the pair; or there may be hostility between members of one pair and members of another.

Simple hostility is the rarer of the two: the only reason I can discover for it is the trespassing of one or both birds of a strange pair upon the "territory" of another (p. 558). In its symptoms there is nothing very remarkable: the birds go into the threatening Dundreary-attitude, often "barking" angrily at each other; finally, one may fly or dive at the other and drive it away, but often the very mild form of hostility involved in staying quite still, assuming the threatening attitude, and barking at the enemy (who is also doing the same) is all that happens.

It is much more interesting, however, to find in these birds what we had best call flirtation, as an accompaniment to their monogamy. The whole thing is very human: when one member of the pair is rather excited and the other is either lethargic or far away, there is no channel for the relief of its excitement. If a bird of opposite sex is in the neighbourhood, however, this would provide the desired relief, and the result is that the "temptation" is often too strong, and a bout of shaking ensues between two birds who are not mated. I have never actually seen such flirtations go beyond a bout of shaking; there is no reason that they should not, except that, as far as I could see, the birds did not seem to be used to each other, so to speak, and so their excitement often cooled down very quickly.

If the rightful mate sees what is going on, it is always roused to action, however lethargic it may have been before. It drives the odd bird away (often by a subaqueous attack with the beak) and then almost always has a strong bout of shaking with its mate. Thus all the anger of jealousy is directed against the usurper, not against the mate—which again is distinctly human! The "erring spouse" is always equally ready to shake with his mate as with the *tertium quid*—and often more so.

Here, again, the sexes are qualitatively alike—either will take

the initiative in flirtation, although from my records the cock seems to do so rather oftener than the hen.

Where there is a simple pleasurable ceremony, for whose performance two birds are necessary, it would seem quite natural that flirtation would occur. If the ceremony is an advantageous one, flirtation represents an overshooting of the mark by Natural Selection—a slight disharmony. “Adultery” I would think very improbable in this species, since the act of pairing is connected with a nest, built jointly by the pair, in a definite spot of their own territory.

#### (v.) Other Activities.

##### *Incubation.*

It appears that both sexes sit, but that probably the hen sits for a much longer time. Mr. A. T. A. Ritchie informs me that when there is a punt near the nest and the hen does not want to return to the eggs, the cock will often drive her to her duties.

##### *Care of the Young.*

After the young birds are hatched, both parents attend on them for some time; but later in the season, when the young are half-grown, the observations of Mr. W. P. Pyecraft (Pyecraft, '11) make it certain that only a single bird, probably the hen, looks after the brood.

Thus here there is no complete and qualitative division between the sexes, except in this last particular.

There is, however, rather more of a quantitative division than usual.

### 6. DISCUSSION.

There are various considerable difficulties concerned with the courtship-structures and actions of the Great Crested Grebe. In the first place, it is clear, from what has been said, that in this bird there is no sexual selection in the ordinary sense of the word; the crest and the courtship-actions are almost identically developed in cock and hen alike.

On the other hand, the crest is only fully developed in the breeding-season, thus resembling true secondary sexual characters; and, as I have pointed out (Huxley, '12<sub>2</sub>) it is used only in courtship, so that if not “secondary,” it is at least “sexual.” Further, the crest is smaller (though but slightly) in the female than in the male, a fact which it is, at first sight, simplest to explain by assuming that the crest was acquired by the cock as a secondary sexual character, and has now been almost completely transferred to the hen (*cf.* similar transference, complete or incomplete, in Lycaenid and other butterflies (Weismann), Reindeer, mammæ of mammals, colours of many birds). We will revert to this point.

The courtship *actions*, however, can scarcely be explained by transference. The Penguin-dance, for instance, can never have been anything but a joint ceremony, equally shared by both sexes. Furthermore, even in the Dabchick, although it (and it alone in the subfamily) lacks all courtship-structures on the head, there is a *joint* courtship-action—the two birds come face to face, stretch up their necks, and emit the well-known cry. This being so, it is fairly clear that the ancestral courtship-actions of the Grebes were not in the nature of a display by one sex, but were joint actions of the pair. There is nothing especially remarkable in this. The display-courtships are, on the whole, more striking, and so have been more frequently described; but (to draw on my own limited experience) Razorbills and Herring-Gulls have very well-marked joint courtship-actions, although the actions are associated with no special structures whatever, and Selous has described other such actions in Swans, Divers, Guillemots, Fulmars, and other species.

I should put forward the theory that the courtship-habits of birds are based upon at least two totally different foundations: in the first place the actions gone through by males alone, apparently as the direct result of sexual eagerness (*solitary actions*), and, in the second place, the actions gone through by male and female together, and perhaps often (though by no means always) connected or associated with nest-building (*combined actions*). Primitively in neither case would there be any special structure or colour associated with the action. For solitary actions this is well seen in the dowdy Warblers, so fully described by Eliot Howard; here the cocks resemble the hens, but go through elaborate droopings of wings and fannings of tail, with bristlings of feathers on throat and crown. Later, Sexual Selection has stepped in, and naturally enough has taken what was already given, and added to it. The same instinctively-displayed parts—wings and tail, throat and crown—are the parts which are especially singled out for the development, first of special colours (Finches, Woodpeckers), then of special colours and structures combined (Turkey, Argus Pheasant, Blackcock, etc.). In combined actions a similar process has been gone through. In the Herring-Gull and Razorbill we have the instinctive actions pure and simple—a direct outcome of nervous excitement. Then, again, something has stepped in and used what was thus provided, and we get combined actions displaying colour (coloured mouths of Fulmar Petrels, Selous), and finally colour and structure, as in the Grebe. The members of the Heron tribe in general, and the Egrets in particular, have also ornamental structures common to both sexes; it would be very interesting to know the course of courtship in these birds. Pycraft ('13) figures a mutual display executed by the Kagu.

The question now arises, How have such colours and structures arisen? By Sexual Selection followed by transference, or by

some other process? Such other process can easily be imagined, and I feel confident that it has played a considerable part. We may call it *Double* or, better, *Mutual Sexual Selection* (*Mutual Selection* for short). Where combined courtship-actions exist, and a variation in the direction of bright colour or strange structure occurred, it would make the actions more exciting and enjoyable, and those birds which showed the new variation best would pair up first and peg out their "territories" for nesting before the others could get mates. The level would tend to be raised generation by generation. Mutual Selection is in a way a blend between Sexual and Natural Selection. The structures and actions arising under it have their immediate origin in the preferences of individual birds, not in anything outside the species, and in their immediate function they are entirely confined to the courtship. On the other hand, the mutual courtship itself, the activities of both birds taken together, may be of use to the species as a whole, in keeping the sexes together when necessary. Then the indirect function of all the shaking-bouts and displays of the Grebe is a function of use to the species, and besides the direct origin there is added an indirect origin under the pressure of Natural Selection.

Mutual Selection has a certain similarity with assortative mating, but is by no means the same thing. Like true Sexual Selection, it encourages an ever higher level in the development of a character, once variation has given it a basis to start from. In the Grebe the line of variation encouraged by Mutual Selection has been the tendency to produce ruffs and tufts of feathers on the head, and to go through actions involving, besides the use of these structures, diving and sporting with water-weed.

The question in the Grebe is complicated, as noted above, by the slightly less developed crest of the hen; this, however, might easily be accounted for by differences in the metabolism of cock and hen. The Discovery and (especially) the Display Ceremonies are also rather stumbling-blocks in the way of an explanation by Mutual Selection; they seem so very like the Displays of solitary courtship. However, even here the second bird plays a part, which in the Discovery Ceremony is at least as important as that of the displaying birds.

What is quite clear, however, is that, even supposing (what to me personally appears very doubtful) that ordinary Sexual Selection has "produced" the structures and the cat-position (we must know more about the habits of other species of the genus to decide this), yet it has gone hand-in-hand with a process of Mutual Sexual Selection as regards the majority of the actions. These actions (like the display of the Peacock, but unlike that of the Warblers) are much too elaborate and much too specialized to be considered as the immediate outcome of any form of physiological excitement. They obviously have a long and complicated evolution behind them, and, as they can only

be performed by the two birds together, there is nothing to account for them as they now stand but some such process as I have just sketched under the name of Mutual Selection

Then there comes the question of the facultative reversal of the act of pairing (or, possibly, only of preliminary pairing-attitudes). The other cases noted by Selous (Pigeon and Moorhen) differ in that the male crouched to the female directly after the act of pairing, who at once proceeded to play the male's part. In the Grebe there was always a long interval before the "reversal of instinct" took place.

In all, however, it is very difficult to see how to account for it, except on the assumption that there has been a reciprocal "transference" of pairing-instincts. This transference may be apparent or real. It is apparent if we believe that the units for such sexual characters are equally present in the germ-plasm of both sexes, and that the characters themselves do not appear in the other sex (or only appear as rudiments) as a result of the great primary sex-difference.

If the transference is real, then one must assume that the zygotic constitution of the two sexes is different in regard to secondary as well as primary differences, but that there is a constant tendency—depending on some as yet unknown process—to transfer such characters to the opposite sex. (Hybridization experiments, where the female of a species can transmit to her male hybrid offspring the secondary sexual characters of her own species, indicate that the first method is the true one.) How else than in one of these two ways can we explain transference in both directions? This is seen, for example, in man, where a male organ, the moustache, appears rudimentarily in the female, and female organs, the maminae, appear rudimentarily in the male: in abnormal cases, besides, the transference may be complete, the organs being completely developed in the wrong sex. Such moustached women and men with breasts again support the idea that the transference is not a real transference, but consists in the removal of an inhibition only.

(I would not trouble to mention the theory that these appearances of characters of one sex in the other are due to descent from a hermaphrodite ancestor, were it not actually the case that Metchnikoff has advanced it. It is enough to point out that if this were so, the primitive mammal must have been a hermaphroditic.)

To us it makes little odds whether there is inhibition alone or transference followed by inhibition. In both cases the character will be in antagonism with the inhibitor: supposing that there is no longer any need to inhibit a character of one sex in the other, then on Darwinian and Weismannian principles the inhibiting "force" will atrophy, and the character, remaining as strong as ever, will appear equally in both sexes.

Apply this to the present case. Birds are for the most part

so constructed that impregnation would take place equally well whether the sexes are in normal or reversed position: that is to say, there is no necessity for keeping to the customary position—and accordingly “reciprocal transference” of the pairing attitudes (whether the transference be apparent or real) may, and quite probably will, take place. If so, then in one of our Grebes the instincts and reflexes for the pairing-actions proper to its sex co-exist side by side with those for the pairing-actions proper to the other sex. It is also obvious, first, that both cannot be gratified simultaneously; and, secondly, that these two very different sets of actions must be associated with two very different sets of emotional states. The bird may “feel female” or it may “feel male,” and according to its feelings, so will it tend to act. But, as we saw before, in discussing the pairing-attitudes, it appears that, owing to the difficulty of coition in the Grebe, the “female” (passive) pairing-attitude has become a mere symbol of readiness to pair. Thus Natural Selection has come in to assist the slow process of transference (at any rate, so far as pairing-attitudes are concerned), and since whatever involves them will probably involve coition itself as well, we have an additional reason for believing that actual reversal of pairing does take place, as Selous supposes, in the Grebe.

At any rate, there can be no doubt about the reversal in the Pigeon and Moorhen. The sudden reversal that here takes place is rather different, but may be explained somewhat as follows:—Here, too, both active and passive instincts are now represented in either sex. A bird is in a state of sexual excitement; this excitement releases itself in the performance of, say, the male part in the act of pairing. The excitement is not always completely exhausted by the act, and, if so, the act is repeated (just as the shaking-bouts of the Grebes are continued for a longer or shorter time, according to the degree of what we may call courtship-excitement). But supposing that general sexual excitement arouses both the male and female emotional states, then the performance of the act once in the male attitude will only exhaust the feeling of “male excitement,” leaving the “female feeling” still a-tingle. The result will be, first, an inducement to repeat the act and, secondly, an inducement to repeat it with attitudes reversed.

Thus such immediate reversal is more or less an accident of heredity, while the Grebe’s reversal is an accident aided by the usefulness of the transferred actions, which thus bring the accident within the sway of Natural Selection.

This treatment of the question is of necessity sadly speculative, but it is our duty at least to try to construct a coherent mechanism of theory to explain the isolated facts of observation.

Finally, a word as to terminology. I have already pointed out (Huxley, '12,) that the phrase *secondary sexual* cannot be applied to the Grebes’ ruff and ears or to their courtship-actions, because

this term always implies a difference between the two sexes, and yet the crest of the Grebe has a sort of secondary sexual look about it—unreflectingly, one would at once write it down as such. This is due to our incomplete classification. We begin by separating out *sexual* characters from all others—these being characters that are different in the two sexes. We divide them into *primary*, *accessory*, and *secondary*. The mammæ of mammals (with the exception of man) have nothing to do with courtship or mating, yet they are usually included under the same heading as the tail of the Peacock, while the Grebes' courtship-structures would be left out in the cold.

Besides the mere criterion of difference in the two sexes, we must have some other criterion—a criterion of use.

It is naturally impossible to draw up any completed classification that will satisfy every case. To do so would be beyond the powers even of a Herbert Spencer—and not of much use when done.

It is enough to point out, first, that our group of Secondary Sexual Characters is a bit of an *omnium gatherum*. Some of them, as the mimicry of the female *Papilio*, or the brown colour of the female Pheasant, are protective, of use to the individual and to her offspring. Others, such as the mammæ of mammals, are of use only to the offspring; others, like the sexual differences in the beak of the Huia, where male and female hunt in couples, one splitting open the wood, the other picking out the hidden grubs, have arisen by a division of labour, and are of use to the couple as a couple. One might go on, but it would be unprofitable.

In the second place, we must recognize as a fact that the existence of individuals of separate sexes with wills of their own has led to the development of what we call courtship—simply a process in which a series of actions is carried out as the outcome of an emotional state based on sexual excitement. All courtship is based on sexual excitement, and characters connected with courtship merit a separate name of their own. This name lies ready to hand in Poulton's term *epigamic*; we must, however, remember that the literal meaning of the term must not be pressed, for in many cases the courtship ceremonies do not lead, directly or indirectly, to the act of pairing. Let us rather turn it the other way about, and, defining an *epigamic character* as one that is used in courtship, go on to define *courtship* as a series of actions based immediately or remotely upon sexual excitement, and, to make ourselves clear, we must add that sexual excitement is not merely sexual desire, but that whole emotional state into which a member of one sex may be thrown by a member of the other. The necessity for the distinction is obvious, if we think of the conditions in Man. Sexual excitement, of course, includes mere sexual desire, and also includes the fighting of males among each other as a result of sexual desire.

If we want a tabular statement, we can draw up something like the following \* :—

- (A) *Characters different in the two sexes.*  
*(Sexual characters).*
- (1) *Primary.* Of the gametes and gonads.
  - (2) *Accessory.* Concerned with the union of the gametes.  
 [Copulatory organs, pairing attitudes,  
 sexual desire.]
  - (3) *Secondary.* All others.
    - (a) Developed through Natural Selection.  
 [Huia beak; mammae; marsupium;  
 incubation by ♀ alone in birds, &c.]
    - (b) Capable of being developed through Sexual Selection.
 

|   |
|---|
| } <i>Epigamic.</i><br>(Courtship characters, i. e. all characters concerned with the relations of the sexes, excepting those connected immediately with coition.) |
|---|
- (B) *Characters similar in the two sexes.*
- (1) Capable of being developed through Mutual Selection.
 

|   |
|---|
| } |
|---|

  
 [Grebes' courtship and crest; Herring-Gull's courtship, &c.]
  - (2) All other characters.

It might perhaps be better, as has been suggested to me, to restrict the term *Secondary Sexual* to 3b, and employ *Sex-limited* where I have employed *secondary sexual*. For one thing, however, this would conflict with Darwinian use; also, I am at present more concerned to show the necessity for new thinking than for new terminology, which will be more suitable in a more general and definitive paper.

I will conclude by hoping that anyone who has the opportunity will observe the habits of the Crested Grebe during the time of pairing-up in early spring; the full courtship of the Dabchick would also be of very great interest. In the near future, I hope to publish a more general paper upon Mutual Selection, so that any notes sent to me on this subject will be gratefully received and acknowledged.

For some further discussion, I refer the reader to the Postscript (p. 559).

## PART II.

### 7. LOCALITY, METHODS, ETC.

Through the kindness of the Hon. Walter Rothschild, I was given a permit to watch, and a punt to watch from, at the Tring Reservoirs. These consist of four large sheets of water in the eastern corner of Hertfordshire. Two have dense beds of reeds

\* Simple sexual *desire*, if we adopt this scheme, we may call an *accessory* sexual emotion. Sexual *excitement* includes this, and all the *epigamic* sexual emotions as well. Pairing attitudes are accessory sexual attitudes. Let it, by the way, never be forgotten that *emotions* and *attitudes* are just as much *characters* as are *colours* or *structures*.

(chiefly *Arundo phragmites*) along one shore, affording cover for the nests of the Grebes, while the banks of the other two are bare. One of these latter is, however, very rich in fish, and a number of Grebes come over every day to feed on it. There, of course, they are nowhere near their nests, and this is of some importance in connection with the meaning of their courtship-actions.

As there were thirty pairs or more on the water, I was never at a loss for "material." In fact, it was often very hard for my pencil to keep up with the birds' actions.

Some of the watching was done concealed in the boathouses, and some from a screened punt, but the major part from the bank. This is in many ways the most useful. With good instruments\* (in this case Goerz-Trieder binoculars  $\times 12$  and a telescope  $\times 30$ ) every action can be easily followed, the birds are not scared, the field of view is uninterrupted, and it is far easier to follow the actions of the same pair of birds for a long period of time.

This, as I say, is best for discovering the general course of events; but just as the microscopist must for certain details supplement his low-power lens with an immersion objective, so here, watching at close quarters must be adopted in order to work out the exact meaning of each separate bit of behaviour. Only when the general course of events has been roughly traced and some hypothesis, however vague, framed concerning it in the watcher's mind, can the fine shades of behaviour have any meaning for him. It is impossible to notice or record everything, and only when some general idea has been gained can the value of any fact be properly appreciated. It is on this account that I would say, always begin by distant watching; otherwise you will not be able to see the wood for the trees.

My brother, Mr. N. T. Huxley, spent much time watching, and several of the incidents here recorded are from his notes. His help was most valuable, and I wish to acknowledge it here. To Mr. James Street, Head Keeper at the Tring Reservoirs, I am indebted for much information, and for his help in arranging hiding-places, etc.

#### 8. ABSTRACT OF SELOUS'S WORK.

I venture to append a short abstract which I had to make of Selous's diary notes for my own use, in hopes that others may find it useful too.

\* A simple apparatus, which makes the task of simultaneous note-taking and observation very much easier, may be constructed as follows:—On to a folding camera tripod is screwed a ball-and-socket camera-holder (special telescope-holders can, I believe, be purchased); the field-glasses are clamped, by means of a long screw and nut, between two leather-lined pieces of wood, and the lower piece of wood can be screwed on to the platform of the ball-and-socket. Both for stationary and moving objects the fatigue of observation is enormously lessened by this means: in addition, one or both hands are left free, and so notes can be taken while watching—a necessity, almost, for reliable work.

The place of observation was a single large sheet of water. In 1900 he watched, fairly continuously, from April 27th to May 25th, except for a break of nine days (May 8th to 17th). At first there was but a single pair of Grebes. A nest was built, probably shortly before May 3rd. On May 3rd the birds paired (or attempted to pair) on the nest. A single egg was laid by May 3rd, a second before May 8th; then came a gap, and on the 17th the nest was destroyed by a boy. There was now a third bird, an odd male, on the lake. The hen "flirted" with him, but the "right" cock drove him away: and, although he stayed till the 22nd, he apparently remained alone and disconsolate all the time. In a single day (May 20th) the pair built a good portion of a second nest. This they continued to build during the 21st, the cock meanwhile building (by himself) a rudimentary nest or platform close to the bank. On the 22nd they were building another (third) nest in the reeds, the cock again building a (second) platform by the bank. On the 23rd there was an unsuccessful, and later a successful, attempt at pairing on the nest. On the 28th the nest seemed abandoned; however, when Selous returned, towards the end of July, there were two nearly full-grown young.

In 1901 he watched for a good part of April, then nearly continuously from April 22nd to May 14th, and then off and on till nearly the end of May. There was again a single pair on the water, and he believes these to have been the same birds as were there the year before. Before he started watching they had made a kind of nest, but a very poor one—a mere sodden heap of weeds scarcely showing above the surface and not at first sight to be easily distinguished from the growing weeds about it. This appears to have been only a pairing-platform. On the 25th they paired on this platform. On May 2nd they executed a regular weed-trick and Penguin-dance, and, some time afterwards, paired again on the platform. As time went on they grew less and less interesting, and it finally grew clear that they were not going to lay. On June 12th, when Selous visited the place after a fortnight's absence, there was no sign of the birds—they had gone for good.

That is the bald diary; now for the birds' behaviour. Under different headings I will summarize the actions of the "1900 pair," and the "1901 pair." (In passing, be it remarked that Selous has no proof that the birds he saw in 1901 were really the same as those of 1900. He says:—"As they were the one and only pair on the same sheet of water, and as the nest was in approximately the same place, I assume and feel personally quite certain that they were." However, there are certain definite differences in behaviour in 1900 and 1901, which make it at least possible that they were not the same pair.)

#### *Nest-building.*

(a) 1900.—Both birds may help in building the nest, usually diving to fetch weeds from the bottom, but sometimes gathering

them from the surface. The mass of weeds brought up by the bird may be very large—a good deal larger than the bird's head, indeed, with streamers trailing beyond the tail. One bird (usually the male) might bring weed to the nest while the other was incubating; when this was so, the sitting bird would generally arrange the weeds with its beak, though sometimes both would arrange the weed together. Weed was added to the nest for at least five days after the first egg was laid.

In the building of the second nest, he saw one morning the cock build a few minutes alone; then both cock and hen build together very hard for about forty-five minutes (74 cargoes in forty minutes); then the hen build a little by herself. The cock, meanwhile, after a short rest, began building a platform, acting precisely as when building the true nest. After fetching 28 cargoes he stopped and rested. The next morning the same great activity was visible; but now the birds were building a third (true) nest. In fifty minutes (including a pause) they brought 100 cargoes of weed, the last 10 or so being brought by the cock alone. This time the cock did not at first desert the nest altogether in favour of his platform, but every now and then diverted a cargo of weed to his own private platform-use. After a rest, however, he reversed his former behaviour; he now began working systematically at the platform, but occasionally took a cargo to the nest. Sometimes he seemed to hesitate between the nest and the platform. The next day there was a little more building, mainly by the cock, and after this no more records.

As to the part played in nest-building by cock and hen respectively, Selous says in regard to this pair:—"The interest taken by the male in the nest has been very marked throughout, more so even—in appearance, at any rate—than that of the female, though in the actual building of it she has been yet more efficient than he" (*l. c.* p. 179). Although he never carried quite so large a cargo as the hen sometimes did, yet his average was as good as hers, and when he swam with his burden to the nest he went much faster.

Sometimes the cock would pass his cargo of weeds to the hen, who (if she did not drop it) would put it on the nest. He never saw this action reversed, nor did he even see the hen help in the building of the cock's platform, or building one for herself alone. The hen alone brought large sticks to the nest (however, the cock was seen to bring a stick to his platform).

In the only recorded case where a nest was watched during incubation (Selous, *l. c.* pp. 161–170), the cock alone brought weeds to the nest, though the hen might arrange what he brought. This is probably of no importance. (The bulk of the nest was presumably built beforehand by both birds together.)

(b) 1901.—This year the only "nest" seen by Selous seems to have been a mere pairing-platform, the actual building of which was not observed. Occasionally the birds would add to it, but in a very perfunctory-looking way, and never more than a few bits of weed at a time.

*Courtship-Actions.*

Selous observed numerous *bouts of shaking*, which he refers to in various ways: *e. g.*, "They front each other in the water, and, with their snaky necks reared up, *tâter* a little with the beak, or make little tosses of their heads in the air" (*loc. cit.* p. 341). He has not, however, attended accurately to the positions of ruff and ears. All that can be said is that his pair (or two pairs) of birds certainly went through the ceremony of shaking, and apparently in just the same way as the many pairs seen by me. As far as I can judge (though judging is difficult) they did not shake quite so often. The important thing to notice, however, is that they did shake, even when they were quite alone on the water. That either jealousy or choice of mates should be the immediate cause, or purpose, of the action is thus absolutely excluded.

On p. 457 he says:—"They front each other with reared necks in the way often alluded to; then, without *tâter*-ing, each throws up the head several times into the air, at the same time opening and closing the long, slender bill." He obviously considers this as being different from the usual ceremony, and adds that he has seen the same action several times, though less pronounced. I think it probable, if not certain, that his eye was here simply caught by a somewhat more pronounced shake than usual, the process referred to as *tâter*-ing being then what I should call a bout of languid shaking; but in the absence of further details one cannot be sure.

A possible but rather rudimentary *display ceremony* is perhaps indicated on Selous's p. 340:—"Once, too, the male flies suddenly some way off over the water."

Then on p. 343 is described a very fine weed-trick and Penguin-dance. It started with a bout of shaking; then the hen dived and came up with a small piece of weed which she apparently dropped. Just before or just after the hen came up (probably before, to judge from my experience), the cock dived too, and brought up a large bunch of weed. They came face to face, and "all at once both leaped entirely upright in the water." The hen took hold of the dangling end of the weed which the cock was carrying, and then they "*chasséd*," "with little waddling steps" from side to side (in the case seen by me, the birds *rotated* slightly back and fro on their axis and did not actually move from side to side. I think Selous is mistaken: such an action as he describes would be impossible on open water). Finally they sank down again, the weed was dropped, and "the male sets off, full of intention, to the nest on the opposite shore." After some time the act of pairing was gone through. This is important as showing that this elaborate courtship-action may sometimes lead more or less directly to pairing, *i. e.* may act (more or less) as an excitant.

Finally, I must just refer to two more scenes. (1) (p. 163):—

"When just in front of each other one dives and brings up some weed, which they both discuss in the friendliest manner, pulling it about, and perhaps eating a little." (2) (p. 340):—"Once one of them—I think the male—comes up with something in his bill, which he dabbles about on the surface and seems to sport with, the other coming close up and appearing to take an interest." This something Selous thinks was a bunch of weed. These actions may bear some relation to the weed-trick, and at all events, even if the main purpose was feeding, the common participation of the two birds denotes that some sexual flavour attached to the act. More light is needed on the habit. (It is, perhaps, connected with the arranging of the weeds on the nest by both birds together, as described on Selous's p. 162.)

*Relations of the pair with other birds of the same species.*

For some days a solitary male appeared on the water where the single pair was living. The hen of the pair apparently\* indulged in a little flirtation with the odd cock—a bout of shaking. This roused the jealousy of the rightful husband, who approached in the usual threatening "Dundreary" attitude, and dived to attack the third bird from below the surface, repeating the diving attack a second time. Later the rightful couple were together and apparently bore down purposefully upon the odd male. The hen rested, while the cock drove his rival away by the attacking dive, and then returned, to go through an "excited" bout of shaking with his mate; first, however, "he swims about for a little, with the head still lowered, and in a proud sort of way."

Thus, as far as jealousy is concerned, Selous's observations are in agreement with mine.

*Pairing-Actions.*

The most important of Selous's observations are concerned with nest-building and pairing; indeed, the full sequence of the pairing-actions seems to have been witnessed by his eyes alone. I have already given a general account of his observations and the deductions to be drawn from them. Here I have simply tabulated some of his detailed descriptions.

1900.

(a) *One bird on the nest.*

- (1) *May 3rd.* The hen was on the nest; the cock swam up and attempted to pair. There is no record of the hen previously "going" into the passive position, but as this was at the very beginning of Selous's observations, he may well not have grasped its significance.

\* I say *apparently*, for Selous is not quite certain as to the birds' identity. This description, however, agrees excellently with my observations.

- (2) *May 3rd.* After this attempt the hen continued to sit; the cock returned at intervals, and at one of his returns Selous noticed the hen assume the passive position. (Here there is again, perhaps, an error of omission. See the next entry.)
- (3) *May 4th.* The hen was sitting; the cock approached at least seven times, and at each approach the hen went into the passive position. In these last two cases (2 and 3) the cock paid no particular attention to the hen, save for the mere fact of his approaching the nest.

(b) *Both birds close to the nest.*

- (4) *May 21st.* The birds were resting after having built most of a second true nest; they then began building again, and after about a quarter of an hour the hen jumped up on to the nest and assumed the passive position. The cock made no response. She soon came off, and the building went on.
- (5) *May 22nd.* Almost exactly the same scene as (4) on the previous day.

(c) *Both birds approach the nest together from a distance.*

- (6) *May 23rd.* (Not recorded which bird led the way.) The hen assumed the passive attitude on the water; when she stopped the cock did the same, but remained in the attitude longer.
- (7) *May 23rd.* After (6) there was a pause of about forty minutes, during some of which the cock (alone) added to the nest; he then ascended the nest and assumed the passive attitude. The hen came up several times, and each time acted as if about to leap up into the active attitude. Meanwhile the cock rose once or twice and then sank down again into the passive attitude. Finally he gave it up and took to the water.
- (8) *May 23rd.* After (7) there was a pause of a few minutes, during which the birds separated and went quite far afield. Then the hen ascended the nest and assumed the passive attitude. The cock came up, behaved just as the hen had done before (in 7), but finally leaped up, and there was an attempt to pair.

[I have put (6), (7) and (8) together because each one seems to lead up to the next. If we were to separate them strictly, (7) should be under heading (b), for the birds remained fairly close to the nest all the time between (6) and (7).]

- (9) *May 23rd.* Nearly an hour later. This has been already described (p. 503). The hen incited the cock by lying along the water; the cock responded by also going into the passive attitude; the hen ascended the nest and assumed the passive attitude, and the cock then attempted to pair.

Thus, in 1900, the three actual attempts at pairing were made

by the cock. Of the "incitations to pair" (when one bird goes into the passive attitude), seven were made by the hen and one by the cock. In the case of this one, the cock ascended the nest directly; as to the hen, on two occasions she was already on the nest, on three she ascended the nest directly, and on two she assumed the attitude on the open water.

1901. (Only a pairing-platform available.)

- (a) *One bird sitting.* (No instances, because the birds apparently do not sit on the pairing-platform.)
- (b) *Both birds near the platform.* No record. (There are two doubtful records where he first notices the birds already at the bed of weeds where the platform is, but here probably he had simply not noticed their previous approach.)
- (c) *Both birds approach the platform together from a distance.* (Fifteen records, counting the two doubtful ones.)
  - (i.) One bird swims straight to the platform, ascends, and assumes the passive attitude.

This was seen ten times; once it was done by the hen, the other nine times by the cock.

- (ii.) One bird assumes the passive attitude on the water near the platform.

This was observed five times; twice it was the female, once the male, and twice the sex was doubtful. (Here, therefore, there is not the preponderance of incitations by the male that was seen in (i.).)

On April 25th the hen assumed the passive attitude, and nothing further happened (immediately).

On May 11th the hen went into the passive attitude, upon which the cock followed suit by going into the attitude too. Some time afterwards the scene was repeated, but with the parts played by the sexes reversed (*cf.* 1900 (6) & (9), above).

This passive attitude, adopted successively by both birds on the water, might or might not lead to one of them ascending the platform and there assuming the passive attitude.

Very often an incitation might have no immediate result, but after a short pause further pairing-actions might be gone through. I will quote a couple of Selous's records for whole mornings.

*April 25th.*

- (a) (There have already been several approaches to the neighbourhood of the nest, and several bouts of shaking.)  
The hen goes into the passive attitude near the nest; but there is no result, and both swim away.
- (β) "Very soon afterwards" they return, and the cock goes straight to the platform, where he assumes the passive

attitude. The hen very shortly jumps up, and pairing takes place.

- ( $\gamma$ ) A little later they again approach the platform, and the cock again goes into the passive attitude upon it. The hen, however, takes no notice, and the cock comes off.
- ( $\delta$ ) He follows her, they both turn, and he repeats his previous action—again without result. He then comes off, and fetching a piece of weed, lays it on the nest. The female comes up, and they lay a few bits of weed on the nest together, but very perfunctorily.

*May 11th.*

- ( $\alpha$ ) Not long after a bout of shaking, they swim together to the weeds. The hen assumes the passive attitude on the water. The cock approaches, "appearing interested" (*cf.* p. 501), but suddenly turns round and also assumes the passive position (but not so pronouncedly), in such a way that the two are tail to tail. Both then rise up, the cock presses past the hen, and goes into the passive position on the nest. The hen makes but a slight response, and the cock, after adding a piece of weed to the nest, swims off in company with his mate.
- ( $\beta$ ) After less than half an hour they swim towards the platform, the cock leading. The cock goes into the passive attitude, and is imitated by the hen when she arrives. There is, however, no further result, and the pair swim off in company.
- ( $\gamma$ ) After about forty minutes they again swim towards the platform; the cock is far ahead, and on reaching the platform he ascends it and assumes the passive attitude. On this, however, the hen apparently becomes coy, for she suddenly turns and swims off; but when the cock follows her, she turns and swims eagerly to him—a pretty piece of psychology.

With this I have summarised the most important of Selous's facts. Others will be found under the separate headings.

## 9. FURTHER DETAILS REGARDING THE RELATIONS OF THE SEXES.

### (i.) Shaking.

The typical bout of shaking is of ten or a dozen shakes, the crest erected in a definite way, the necks stretched straight up to their fullest extent, the two birds facing each other at a distance of a few inches only.

It is usually initiated by the birds swimming towards each other at a moderate pace, meanwhile gradually raising their crests and necks, and giving a repeated double call rather resembling that up-and-down call of the Snipe as he sits in the marsh.

At the beginning of a bout the attitude often seems to express an extra degree of excitement, but especially so after a "flirtation"; the ruff is a little more circular, the ears pressed forward to their limit, and the neck curved over a little at the top, so that the heads and beaks are pointing somewhat downwards; this attitude never lasts long, and soon subsides into the ordinary one, in which the birds give somewhat the alert impression of a couple of smooth-haired Fox-terriers. As a general rule, habit-preening does not begin until after a few shakes, and usually gets a little more frequent as the bout goes on.

Usually, the bout is closed by the two birds simply drifting slowly apart, and gradually lowering their crests, or else one or both of them may turn sharp up into the wind with a more sudden closure of the crest.

In the longest bout seen the pair gave 84 shakes, while in the shortest seen (which is also the shortest possible) each bird only gave a single shake.

Often there are somewhat abortive bouts, without enthusiasm on the part of either bird; these do not last long, never for more than seven or eight shakes, and the crests and necks are often not erected to their proper position. There are degrees of excitement. In the lowest the neck is in the graceful curve of the ordinary swimming position, the ruff is relaxed, and the ears are scarcely half-raised. In the next stage, the ears are fully raised: then, the ruffs are slightly expanded as well: then, the neck is raised more and more: and finally both ruff and neck come to their typical extension.

A certain frame of mind is necessary for shaking, and sometimes even the expressed desire of the other bird to shake cannot arouse this state (see p. 544); for still further details the reader is referred to section 10.

## (ii.) Nest building.

There is one curious habit connected with nest-building about the significance of which I am not at all sure: this is the trampling down of the nest. Lying in a punt in the reeds I have heard this trampling, first on one side, then on the other—squelch, squelch, squelch,—sounds of some creature trampling heavily with alternate feet on something sodden.

This is the water-birds treading down their nests. The Grebe does it, and, I believe, the Coot, and possibly other birds as well. The one occasion where I saw it well is worth recording, partly on this account and partly for another reason, as will shortly be seen. A pair had been fishing and resting; the cock then stayed perfectly still, not very far from the nest, for some minutes, and the hen went off and fished. The cock moved slowly towards the nest, and was there joined by the hen; after a short time the hen got on to the nest, there, in the usual ungainly upright position, stamped heavily twelve or fourteen times on the sodden weeds, and then settled down into a sitting position. She

remained thus for about two minutes, then got off, apparently put a few bits of weed on the nest, and swam off with the cock, who for his part had remained quite quiet all the time. When I went to inspect the nest later in the day, I found that there were no eggs, and that it seemed to be a mere pairing-platform—old, sodden, low, and covered with excreta.

This is thus the only case on record where a bird has ascended the pairing-platform or nest except for the purpose of incubation or to go into the passive pairing-attitude.

The cock of course uses his special platform to rest on, so it is possible that the pairing-platform is used by the hen as a corresponding resting-place. Or, in amplification of what I have already suggested (p. 518), that when the true nest is built the hen incubates longer and so uses that as a resting-place, the cock has his platform, and both sexes use the pairing-platform.

A third possibility (but not a very likely one) is that the sitting on the nest (platform) in this case was in reality only the first step towards assuming the passive attitude, but that the bird's sexual excitement was not high enough to complete the action.

Most probably this, like many other bits of behaviour, was an "accidental" and useless release of energy, rendered possible by the mechanism of the bird's mind.

### (iii.) Details of the Relations of Different Pairs to each other.

I have thought it worth while to go into this at some length, in order to show how extremely complicated the birds' mental states are, and how like may at a moment's notice be turned into dislike. We will consider the relations of a pair with an odd bird in the neighbourhood.

Let us for brevity's sake call the three birds X, Y, and "Y." "Y" is the intruder, whom we also call *the odd bird*; X and Y are the pair, or *the paired birds*, cock and hen; Y is of the same sex as "Y," X of the opposite sex. This will serve when we want general formulæ. In particular cases, where the sexes have been accurately observed, we can employ a similar formula, e.g. ♂, ♀, "♀," or ♂, ♀, "♂," according as the odd bird is a cock or hen; or we can simply say "Y" = "♂" or "♀" as the case may be.

Now for our general statements:—

1. The disposition of X towards "Y" may be (a) well-disposed—in other words, X may be at the moment flirtatiously inclined in general.

(b) Indifferent. Then X does nothing in particular, and Y drives "Y" away.

(c) Hostile. Then X helps Y drive "Y" away;

but the actual initiative, the first step towards a "flirtation," may be taken (i.) by X, (ii.) by "Y."

2. The disposition of Y towards "Y"; this is always more or less hostile, but there are variations (*a*) in the time at which the hostility is first shown, and (*b*) in the way in which it is shown.

(*a*) *Time.* Y becomes hostile

- (i.) on passing near "Y," although "Y" has been quite inactive;
- (ii.) on passing near "Y," but only after "Y" has first gone into the hostile Dundreary attitude;
- (iii.) only when X (its mate) makes as if to approach "Y";
- (iv.) only when its mate actually begins to shake with "Y";
- (v.) only after its mate has shaken for some time with "Y."

(*b*) *Method.*

- Y may (i.) simply swim at "Y";
- (ii.) assume the hostile attitude and swim towards "Y";
  - (iii.) fly at "Y" along the surface of the water;
  - (iv.) dive and endeavour to come at "Y" with the beak from below the surface.

In addition, these actions may be gone through in succession; if so, they are always gone through in this order, except that (iii.) and (iv.) may be reversed.

3. The disposition of "Y."

- "Y" may be (*a*) simply indifferent to the presence of the pair;
- (*b*) hostile to the pair;
  - (*c*) eager to "flirt" with X.

Here again the initiative may be taken (i.) by X, (ii.) by "Y."

Combinations of these pretty well exhaust the possibilities; here I shall give an idea of the most usual happenings.

When the two birds of a pair are swimming along together, and they pass close to a third bird, X usually takes no notice, and Y goes into the Dundreary attitude while passing "Y," sometimes swimming a little towards "Y." The odd bird, "Y," may be, and usually is, entirely indifferent to the pair, though it may adopt a threatening (Dundreary) attitude as a response to the similar threat of Y; and I once saw "Y" take the initiative in threatening.

On the other hand, I have never seen any sign of a flirtation between X and the odd bird in these circumstances.

That X should be willing or desirous to flirt with "Y," it seems necessary that its mate should either be absent or fairly distant, or, if close at hand, lethargic (see section 10, record 1), or unwilling to perform any courtship-actions. When a flirtation does ensue, "Y" may have taken the initiative, by swimming close up, calling, or going into the searching Dundreary attitude; or X may have taken the initiative by swimming up to a

perfectly innocent "Y." The former, from my records, seems to be more usual (as one would expect: it is more probable that a lone bird will be more eager to "shake" than one whose mate is near at hand).

One interesting fact emerges from table A (p. 542): in seven out of eight cases where there was a flirtation and I could be sure of the sexes, "Y" was a female, while of the cases where X was indifferent or hostile to "Y," "Y" was female in about half the number.

This is probably not merely chance; I believe that here the male Grebe possesses a little more of the normal characteristics of males.

I have several records where "Y" is very threatening from the first; here the pair always seem to make common cause against the intruder. I do not see how these cases can have anything to do with a desire of "Y" to shake, etc., nor is there in the behaviour of the pair any sign of jealousy. There seems to be only hostility, and I am disposed to think that in all such cases the pair has been trespassing on another's territory (see p. 558).

Y may drive "Y" right off, or content itself with going into the threatening attitude. "Y" is always driven off if Y sees a flirtation going on; but when the pair are simply swimming past the odd bird, Y contents itself with going into the threatening attitude (in one doubtful case only was "Y" driven away); here we have association at work. In cases where "Y" hangs about, it may be driven off by Y even though no flirtation takes place.

If Y wishes to drive "Y" off, it usually dives. Sometimes "Y" is completely taken by surprise, and, as it flies off, its place is at once taken by the jealous one. Presumably Y's beak sometimes actually comes into play, which must be very unpleasant for "Y." At other times "Y" sees Y dive, and is off at once.

The mere presence of an odd bird is not sufficient stimulus to induce a bout of shaking between the pair. Shaking is usual (though not invariable) after a flirtation and subsequent driving away of "Y."

When a bout of shaking does take place after flirtation, it always seems to begin in the *forward position*. This position in its full development I have never seen except after an odd bird has been driven away, so that we have here an interesting example of a definite form of courtship-action used exclusively under the influence of jealousy.

Let us close with one or two interesting cases—actual happenings. Here is one:—

1. The cock of a pair, saw an odd bird (? sex) near by, and drove it off, by flying at it, spluttering along the water. He then came back towards his mate, and from his attitude I thought

he was going to shake with her. However, he then saw another odd bird (? sex) not far off, and, his pecker presumably being up, went off and drove it away too. After this he came back, and a short but vigorous bout of shaking ensued. I do not suppose he would have driven the second bird off if he had not been roused by the first.

2. Then a second:—An odd cock was seen “in a very threatening attitude,” some twenty yards away from a pair. They got close together, the cock going into a fairly good threatening attitude: they then swam, the cock leading, towards the intruder, but suddenly turned tail; however, they soon faced round again, and waited a bit. “Y” was now only about ten yards off. Then the pair swam a little away (this is very odd) and then all three dived; as a result, “Y” was driven a short distance away, and the pair made as if to shake, but did not. “Y” approached again, and the same scene was re-enacted almost identically (most ludicrous to watch, it was!); finally came several long dives on the part of all three birds, and “Y” was driven right off. Strange to say, no shaking followed.

Here, in face of an obviously hostile third bird, the pair united at once in common action (*cf.* Selous, in the case of Ring-Dotterel).

3. Once I saw the odd bird approach “like a dolphin”—progressing for the most part subaqueously, but now and then lifting first head and then back out of the water, only to disappear again. What this may mean I do not know.

4. In one case where there had been a flirtatious shake (“Y” = ♀), the rightful hen came up, and instead of at once driving “Y” away, started shaking, so that for a short time there was a *parti à trois*. She then drove “Y” off, and then returned and had a long shake with X. This I have only seen once.

5. Once where “Y” (a hen) had called, X swam almost up to her, but at the last moment was seized with a “fit of repentance,” returned to his mate, and shook with her. Perhaps it was not repentance at all; perhaps on seeing her mate go off towards “Y,” the hen gave some sign that she was ready to shake, or rather that she was roused enough to shake. This would be all the cock wanted, and, seeing this, he came back. This is only a possible explanation, but it at least has its parallels in our own affairs.

6. A variation on the above was given by the same cock a little earlier; this time he had actually shaken a bit with “Y”, but on seeing his mate approaching, he suddenly turned on “Y” and drove her off. The rightful hen did not trouble herself further; but there was, curiously enough, no shaking on the part of the pair.

7. An odd bird approached; Y (? sex) swam towards it. Both went into the threatening attitude and remained perfectly motionless, looking very fierce at each other at a distance of only

five or six feet, calling ("barking") the while. At length Y came up with a loud trumpet call, there was a great flying of all three, "Y" was driven off, and the pair had a short bout of shaking.

This is something like 2—hostility evinced from the start by "Y," the pair acting together against the intruder.

8. I only once saw two pairs come into conflict; and unfortunately could not make out much. There was much diving, and, finally, two birds went off together; the other two had a short bout of shaking.

Finally come the two cases where apparently two "odd birds" meet.

9. In one I saw a short bout of shaking. Then the cock went off in the search (Dundreary) attitude; the hen, though quite close, took no notice, and the cock finally went right off. I am almost sure it was this same hen who later shook with another cock.

10. In the other (p. 546), a cock came flying over, settled near a hen, and they had a short bout of shaking. Then the cock dived; the hen still kept her ruff up expectantly, but the cock came up a long way off, swimming away from her, and she put it down; and so the scene ended.

In both these cases it is pretty clear that the birds were not a pair, but that, finding themselves together, they tried a bout of shaking. This, however, was somehow not satisfactory—it was not what they were accustomed to; and they parted. Both times one bird (as it happened, the male) was obviously searching for his mate, and it may be that this "prepossession" led to the flirtation being quickly broken off.

TABLE A.  
Disposition of X to "Y."

|   | Sex of "Y." |    |   |
|---|-------------|----|---|
|   | ♂           | ♀  | ? |
| (a) X flirtatiously disposed to "Y" ..... | 1           | 7* | 1 |
| (b) X indifferent to "Y" .....            | 4           | 3  | 2 |
| (c) X hostile to "Y" .....                | 1           | 2  | 2 |

\* In two of the seven cases, X (♂) later became hostile to "Y" when his own mate approached, and in a third case he was almost entirely indifferent to "Y."

TABLE B.

Disposition of "Y" to the pair.

Figures in brackets include doubtful possibilities.

|  | Sex of "Y." |     |       |
|--|-------------|-----|-------|
|  | ♂           | ♀   | ?     |
| A.—X and Y (the pair) swimming together in a definite direction. |             |     |       |
| (a) "Y" (the odd bird) threatening:                              |             |     |       |
| (i.) "Y" takes the initiative .....                              | ...         | ... | 1     |
| (ii.) "Y" does not take the initiative .....                     | 1           | ... | ...   |
| (b) "Y" flirtatious .....  | ...         | ... | ...   |
| (c) "Y" indifferent .....  | 1           | 5   | ...   |
| B.—X and Y fishing, resting, etc.—not swimming.                  |             |     |       |
| (a) "Y" threatening:   |             |     |       |
| (i.) "Y" takes the initiative .....                              | 1 (2)       | ... | 0 (1) |
| (ii.) "Y" does not take the initiative .....                     | ...         | ... | ...   |
| (iii.) Doubtful .....  | ...         | ... | 0 (1) |
| (b) "Y" flirtatious:   |             |     |       |
| (i.) "Y" takes the initiative .....                              | 0 (1)       | 3   | 1 (2) |
| (ii.) "Y" does not take the initiative .....                     | ...         | 2   | ...   |
| (iii.) Doubtful .....  | 1 (2)       | 2   | 1 (2) |
| (c) "Y" indifferent .....  | 2           | ... | ...   |

## 10. RECORDS FROM MY NOTES.

Here follow a number of actual incidents which may be of service to any future observers. Among other things, they show very clearly the individual differences between different pairs.

I have numbered these scenes, and append here a little index showing where descriptions of various courtship activities may be found:—

| Courtship-action.                       | Scene.         |
|---|----------------|
| Bout of shaking .....                   | 1-12, 15.      |
| Display ceremony .....                  | 4, 7.          |
| Discovery ceremony .....                | 1, 4, 10.      |
| Diving alone .....                      | 3, 5, 12.      |
| Weed-trick .....                        | 2, 6, 12.      |
| Complete Penguin-dance .....            | 8, 11, 12.     |
| Flirtation .....                        | 7, 12, 14, 15. |
| Hostility to birds of other pairs ..... | 8, 9, 11-15.   |

## 1. April 10. 4.8-4.40 p.m.

A pair, ♂ and ♀ easily distinguishable.

When I first saw them they were indulging in a typical shake of moderate length, ended by one turning away from the other. After this for about 17 minutes they moved slowly in one direction, the hen always leading the way. When not swimming she did some fairly vigorous preening. Sometimes she was 30 or 40 yards ahead of her mate, but when she got as far away as this, she always swam back and joined the cock. (Pleasure merely in each other's presence, and dislike of being separated, is marked in many monogamous birds.) He spent most of the time with his head under his wing, but now and then woke up, looked about him, and gave some rapid strokes towards the hen; occasionally he did a little preening. Not only was the hen more active and awake than the cock; she was also more emotionally inclined. She kept on coming close up to him and shaking her head slightly, trying obviously to stimulate him to respond. The first time she did this (4.13) the cock just raised his head from under his wing, gave a couple of scarcely-visible shakes, without extending his neck, and relapsed into somnolence; while to her later advances he responded not at all. She was very restless; would swim up, give two or three shakes, swim a few yards off, turn, come back, swim off again, and so on, maybe three or four times in quick succession, then she would make up her mind and swim steadily off, only to come back again after a few minutes' interval. This she did four times. By 4.26, after 17 minutes of this, she began to think of feeding, for she dived twice. Her previous emotional state had, however, not quite died down, for she then came back right up to the cock, though this time without any actual shaking. At 4.32 she went right off, and began fishing a good eighty yards away. At 4.35 she caught a big fish, swallowed it, and went on diving. The cock meanwhile rested and preened himself, and at 4.40 I lost sight of both.

This well illustrates the way in which the physiological and emotional states of individual birds vary from hour to hour. That the male was capable of normal excitement is shown by his shaking in the usual way at 4.8. This exhausted his emotional fires for the time being, but left the hen still with a good deal of pent-up excitement. It seems (as one would expect) to be "no fun" to shake all by oneself, and so her potential energy had to be released through other channels, giving as a result the quarter of an hour's restlessness.

At 4.43 a bird which is recorded as "♂, probably the same as that lost sight of at 4.40," went into the regular Cat-position, and its mate appeared in the usual way, rising erect closely from below the surface. (Discovery Ceremony.) If they were the same pair, it is obvious that the half-hour's rest had restored to the cock all his emotional energy, and the variation in emotional states is still more clearly brought out.

**2. April 11. 1.50-2.30 p.m.**

A pair: ♂ and ♀ rather hard to distinguish.

1.50. I just saw the end of a shake.

1.51-2.0. They swam about vaguely, occasionally diving.

2.1. I was watching one (sex?) when suddenly the other came into the field of view, carrying in its beak a big bunch (bigger a good deal than its own head) of dark, ribbony weed, which must have just been fetched from the bottom. The bird was swimming fast and rather low, in the ordinary position adopted when approaching its mate with weeds. It came right up to its mate, and the pair shook (without habit-preening) for 10 seconds or so. Then (I am practically, but not absolutely, sure) the weedless bird took some of the weed, and shaking began again. This lasted a still shorter time—"then" (I quote from my notes) "both birds turned head to wind—and lo, their ruffs were down, and there was no weed in their mouths!" They then swam off together.

2.3-2.10. Lost to sight behind reeds.

2.11. Out again. They turned to face each other, and then shook five or six times. To start with, strange to say, their necks were right down in the normal swimming position. As they shook, they gradually raised them till they were half pear-shaped. They then stayed motionless for about 20 seconds, then shook twice, and swam slowly apart.

2.12-2.27. For fifteen minutes, as near as may be, they did absolutely nothing—merely drifting and swimming aimlessly about.

2.27. One preened itself; and then they faced each other, shook 7 or 8 times, turned up wind, and swam off into the reeds.

**3. April 11. 5 p.m.**

I caught a pair in the middle of a bout of shaking. There were 7 or 8 shakes, with an occasional habit-preen, and then they swam apart, but with their necks still straight up and crests erected. One stayed nearly stationary; when the other had got some fifteen yards away, the stationary one dived. It came up close to the other, and shaking began again, much as before. After seven shakes they stopped and went off together, only gradually letting necks and crests subside to their ordinary positions. It must have then been feeding-time, for they took three long dives across to "Fish Corner" and began fishing.

This scene is unusual, for diving as a part of courtship-ritual is usually associated either with the cat-position or with the weed-fetching. The slow subsidence of neck and crest after shaking is also not common.

**4. April 12. 8.20 a.m. A pair.**

After drifting about for 5 minutes or so, they began shaking. They shook 10 or 12 times, with habit-preening; they then put

their ruffs down, and drifted slowly apart. When they were separated by about twenty yards the cock dived and came up close to the hen, upon which the pair began shaking once more. After a very few shakes they stopped, the cock put his crest down and swam off at a moderate pace; the hen, however, stayed where she was and kept her crest up. When the male was about forty yards off, he went into the cat-position: on looking at the hen, I saw that she had done the same, with wings fairly well arched. The cock had at first scarcely arched his wings, but when the hen went into position, up went his wings to the full for an instant. It was but an instant, for then he dived; "a ripple was seen coming quickly towards the hen along the surface of the water (most exciting!)" ; when it had nearly reached her, the cock appeared, slowly erecting himself out of the water in the usual way. He seemed to be facing her all the time. He settled down, and a very long shake began. There was no habit-preening for the first ten or a dozen shakes, nor very much at any time. Eventually they drifted apart, put their ruffs down, and did nothing in particular for the five minutes or so I went on watching.

This shows again that courtship-diving may take place apart from the cat-position or from weed-fetching; and also that, although the cat-position seems usually to be employed as a stimulus to induce a bird of the opposite sex to do the Penguin-dive, yet the diving bird, too, may go into the same attitude before it dives.

#### 5. April 12. 8.50 a.m.

A cock flew over from another reservoir and alighted near a hen. In under a quarter of a minute they had begun shaking. They only shook seven or eight times, with habit-preening, and then drifted apart. Soon the cock dived; the hen kept her ruff up, but the cock had dived away from her, and appeared a long way off. On seeing this, the hen lowered her crest.

This seems to show that when one bird dives, and dives deep so as to produce no ripple on the surface, the other is left in a state of suspense which is exciting enough to make it keep its crest up.

Whether the two birds were a paired couple or not could only have been proved by further watching; but I should say that they probably were not a pair, but that their close proximity and the absence of their real mates excited them. The emotion found expression in the usual actions, but then the strangeness of the hen proved unsatisfactory to the cock.

#### 6. April 16. a.m. A pair.

I caught them shaking. After 6 or 7 shakes they separated; when they were some way apart, the hen went into a feeble cat-

attitude. The cock dived, and came up five or six yards off with a fair-sized bunch of weeds in his mouth. Strange to say, he was in something very like the normal swimming attitude, though his ruff was fairly well erected. On seeing him the hen to my surprise put her crest down, turned, and swam away, and the cock could do nothing but drop his weed, lower his crest, too, and swim after her. Nothing particular happened in the subsequent five or ten minutes.

Here, when the emotional excitement reached a certain pitch, the hen had a sudden attack of "coyness" (*cf.* similar behaviour in the female Redshank, Huxley, 12<sub>1</sub>, p. 651).

#### 7. April 16. 1.30 p.m.

I caught a pair shaking. Suddenly, and for no apparent reason, the hen flew off, flapping along the water. I followed her, but she simply settled in an ordinary attitude. However, on looking back at the cock again, I found him engaged in shaking with another hen. The first hen, therefore, must have been a casual acquaintance, who departed hastily on seeing the rightful mate coming up. The rightful pair shook 4 or 5 times (without any habit-preening), and then on a sudden the cock flew a few yards off, and put himself into the best cat-attitude I have seen. He turned round, first one way and then the other, just as the Peacock does when in display, and then, gradually un-arching his wings and raising his neck, swam back to begin shaking once more with his mate. This time they shook about ten times; habit-preening began about halfway through, and at the same time the ruffs were half lowered. Then they both dived nearly simultaneously, and I saw them no more (they must have made a very long dive and got into the reeds).

This is a very good example of the pure Display ceremony (see p. 513), here induced by the extra excitement of the previous "flirtation."

#### 8. April 17. 1.30 p.m. A pair.

I saw a pair shaking; they went on for a very long time (no notes as to habit-preening), and finally one (sex?) dived. As it did so, I saw the other convert its crest into an "Elizabethan ruff"; after a few seconds it too dived. Both came up with weed in their mouths, fairly close to each other, and the usual Penguin-dance was gone through, followed by a short bout of shaking. They then put their crests down, and swam off together. To progress faster, they took three long dives, each time going under almost simultaneously. After the third dive they came up close to a single bird (sex?), which at once went into the Dundreary-attitude. Then all three dived in quick succession, and after some time two, which I presume to have been the original pair, came up close together, and at once began to shake, starting in the excited forward position. After that I lost sight of them.

## 9. April 17. 2.25-3.5 p.m.

- 2.25. A pair were swimming about fairly close to each other, resting and preening by turns.
- 2.28. The hen three times went into the Dundreary-attitude with short intervals between.
- 2.35. After resting for some minutes, she barked five times in succession, and relapsed into the resting position, never, however, shutting her eyes.
- 2.44. One bird swam off out of sight; the other barked several times. After a little bit the first one came back into view, and they both began preening themselves.
- 2.50. Suddenly a third bird (sex ?) came swimming towards them, and when about thirty yards off went into the Dundreary-attitude, at the same time giving five long, loud, rolling barks. At once both birds of the pair put themselves into the same attitude, and faced round on the third Grebe, uttering at the same time a series of short, low, and quickly-repeated barks. The intruder changed its course a few points and went off towards the reeds; directly it was out of the way, the pair "got up and shook." The shaking, however, only lasted for a short time, and they then relapsed into their previous state of preening and swimming about.
- 2.55. After they had swum out of sight and back again, I saw one of them (sex ?) go to one side in Dundreary-attitude, calling repeatedly, and on looking further afield discovered the reason for this in the shape of an intruding single bird (sex ?) (probably not the previous intruder) who was approaching in the same position and uttering the same cry, about thirty yards away. This single bird then dived and came up not six feet away from the other. They were now in an attitude I had never seen before—best described as the most hostile possible form of the "Dundreary," differing from the typical form chiefly in that the heads were not quite so low down. For some time they stayed thus facing each other, still, or moving a little forwards as if to attack, and then at once thinking better of it, and all the time giving the low, quick bark. Finally the second bird of the pair came up, giving a loud grinding trumpet-call, and then all of a sudden there was a great flying of all the three at each other, and at the end of it one bird went off, and two (undoubtedly the original pair) were left together; they at once approached and shook; the shaking, however, only went on for a short time, and then, after a few minutes' preening, I lost them.

Here, twice over, it is obvious that the presence of a third bird has screwed excitement to the shaking-point; the remarkable thing in both cases is, that the bouts of shaking thus induced should last so short a time, whereas on another occasion (April 16, 1.30 p.m.) a similarly-induced bout ended very differently.

**10. April 17.** p.m.

A single bird (I think a hen) was swimming about, gave the double-trumpet twice or thrice, and then looked about. Another bird, some forty yards off, noticed the call and turned, and they swam quite slowly towards each other. When they had reached each other, they began shaking, very excitedly at first. After six or seven shakes, the hen suddenly turned straight away from the cock, and flew or spluttered some eight yards away. She then put herself into a fine cat-attitude, and began turning from side to side—all this without uttering any call. The cock watched her thus for several seconds, and then dived and swam just below the surface, making a ripple, and as this approached her, the hen drew her head down ever lower on her breast. When four or five feet off, the cock put his head and neck out—apparently to see where he was, for he disappeared again at once. When he finally appeared it was three feet beyond the hen, and he was facing away from her as he “grew out of the water” into the customary ghostly Penguin; he turned to face the hen as he subsided, and finally shook with her. This bout was only a short one, however, and after it they swam some distance apart. After a minute or so the hen gave two double-trumpets, but then relapsed into the state, from which the cock had never emerged, of doing nothing in particular, and in this state some minutes later I left them.

This differs from the typical Discovery ceremony in two points: (1) the birds do not usually swim together thus, but one dives at once, (2) the cock does not generally wait and watch the hen's display (“cat-attitude”) before making his “ghost-dive.”

**11. April 18.** 10.40 a.m. to 12.17 p.m. A pair.

10.40. I saw a pair close together, the cock and hen easily distinguishable.

10.45. They preened close together for some time.

10.48. They swam off together and got close inshore.

10.52. Both dived once or twice, I think for fish.

After preening themselves for a bit (10.56–10.59) they began diving again near the bank, and the cock caught a small fish.

11.0. They came up close together and began shaking; but they only gave three or four shakes, and their ruffs were scarcely half expanded.

11.2. Again after a dive they came up close together, and again had a bout of shaking. This time they shook 10 or 12 times, and their ruffs were well up; there was no habit-preening.

11.8. After some minutes' swimming about further out from the bank, occasionally picking up things from the surface of the water, they swam together with outstretched necks (the forward swimming-attitude); the hen swimming much the faster. As they approached, and while their necks were still stretched forward, they began to shake, but

they never put their ruffs properly up, and after five or six shakes, during which the necks were gradually raised, but not to their full height, the shaking degenerated into habit-preening, and this into real preening.

- 11.10. They swam off and began diving again near the bank. After the second dive they came up only about three yards apart, and both shook their heads three or four times; the shaking was not very vigorous, and "had not much reference to the other bird"—*i. e.* they did not come and face each other in the customary way. They then swam out from the bank. As they passed a solitary hen some way off, the hen of the pair, who was between her cock and the single bird, went into the Dundreary-attitude. From 11.12–11.22 they swam about, picked things off the surface, fished, and took long "progressive" dives, ending up near the opposite bank of the reservoir.
- 11.23–11.28. After a dive they came up fairly close together, and swam towards each other with outstretched necks, which they gradually raised as they neared each other, beginning to shake their heads at the same time. A prodigious bout of shaking ensued, and was followed by diving for weed, swimming together, beautiful penguin-actions, and final bout of shaking. The whole thing has been already described in detail in section 4c, p. 499. Here suffice it to say that the hen began habit-preening before the cock, and once begun, practised it more than he. She too dived first, came up first, and had more weed in her mouth.
- 11.29–11.39. They swam back towards where I first saw them, often picking things off the surface. A solitary cock was close to the line of route, and our cock went into the Dundreary-attitude as he passed the odd bird.
- 11.40. They dived. The cock came up first, and gave a couple of shakes "to himself" (*cf.* 11.10). Then the hen came up, and they shook together four or five times, but without raising their crests at all, or their necks to their full extent; they then went on fishing near the bank.
- 11.49. They stopped fishing; the hen began preening. The cock swam towards her from some thirty yards off. She came a little way to meet him, and they shook seven times with their ruffs half-up. The bout ended in habit-preening.
- 11.56. After swimming about and preening they had another shake. This again was a very long one, like that at 11.23 (I did not count the number of shakes, as I was more intent trying to make out various details of attitude); indeed it was almost a precise replica of this previous long one, and had the same sequel—a fine "Penguin-dance." The only differences I could see were that their ruffs were not quite so "sun-like" before diving, that both brought up plenty of weed, that I am almost sure a good deal of the weed was

eaten, and that the final bout of shaking was less than half as long.

- 12.0-12.15. The birds now swim about, preen themselves, dive, and pick things off the surface. The cock is now more active in searching for food than the hen, while previously the reverse had been true. At 12.8 they passed another bird (sex ?). My hen went close up to it, then swam rather rapidly away, then close up again. However, nothing happens, and neither bird goes into the Dundreary-attitude.
- 12.15. They pass near a single bird, which I think is a hen—the cock, who was leading, took no notice of it; but the hen went into the straight-necked (or angry) Dundreary-attitude and, without giving any call, swam at the third bird. The solitary one turned, swam away, and finally flew some fifteen yards off, upon which my hen turned, assumed a normal attitude, and swam back towards her mate. No shaking or other expression of emotion, however, took place.
- 12.17. They began fishing close inshore.
- 12.18. I took my eyes off them, and when I looked back could no longer be sure of them among the several birds along the shore.

My notes on this pair I have given in full because I had them under continuous observation for a considerable time (over an hour and a half). Their behaviour is of interest in various ways. In the first place, we see how, in this pair at least, outbursts of violent emotional actions alternate with calm periods during which the birds rest or feed, occasionally indulging in a short and rather languid bout of shaking. When passing near a third bird, one of the pair usually went into the threatening attitude (Dundreary). In every case I could be sure about, the bird that did this was of the same sex as the third or single bird. The pair had marked idiosyncrasies of its own, both as regards what it did do and what it did not do: and besides this, both cock and hen had tricks of their own in performing the courtship-actions, which I think were certainly permanent and not due to changeable physiological states.

All this took place on the reedless reservoir, where there are no nests, and consequently far away from the scene of actual pairing. Physiologically, therefore, the "courtship" and the act of pairing are entirely detached from each other.

## 12. April 18. 2.30 p.m.

A pair shook about forty times, with habit-preening. At the end they turned their backs on one another, still shaking and habit-preening—to themselves, as it were,—but gradually letting their crests sink. When about twenty yards apart they turned, swam slowly together, and shook a little, but without raising their crests. Then for about a quarter of an hour they stayed quietly facing each other, preening themselves. After this there was a short bout of shaking, then a rest, then another bout of some thirty

shakes. This, like the long first bout, was followed by their turning their backs on each other and shaking "to themselves"—a couple of shakes and 6 or 7 "habit-preens." This time, however, instead of turning, both dived suddenly and simultaneously; they emerged about forty yards apart, swam rapidly in the forward swimming-attitude towards each other, and shook about fifteen times. After a couple more short bouts, one of them (sex?) drove off a third bird which had been following at a little distance, then came back and shook with its mate. Another short bout with ruff down, and then they rested for some time, waking up once to give four languid shakes. A solitary hen suddenly called some way off; my cock roused himself and advanced towards her. She first retired, but then came towards him, and they began to shake. This did not last long, however, for the cock's rightful mate dived and came up between the two that were shaking. She drove the stranger away, and then came back and had a bout of twenty shakes or so with her mate. After a time of resting they had a longish bout—some twenty-five shakes—and as before turned back to back. This time the procedure was again altered. When 20 or 25 yards away, the cock dived; the hen waited for him, with her ruff down. He appeared after nearly half a minute, with some weed in his bill, a little closer to the hen. He approached, but dropped the weed before getting to her, and they only indulged in a short bout of shaking. They then rested and swam to and fro, till a solitary hen appeared near by, when my cock went up to her. They started to shake, but suddenly the cock changed his attitude and drove the stranger away. This change of front was probably due to, and certainly coincident with, the approach of its rightful mate. Then both swam off in one direction. The cock, who was leading by about 50 yards, went close up to a solitary hen who was calling, but at the last moment turned and swam back to his mate, with whom he had a short bout of shaking. After a long spell of swimming about and fishing, they called to each other, approached, and had a long bout of shaking, with less habit-preening than usual. Again they ended by doing the "back-to-back" trick, and again they dived simultaneously. This time, however, when they came up (some twenty yards apart), though the hen had nothing, the cock had a very large bunch of weed in his mouth. They swam together and went through the regular penguin-actions, he shaking the weed from side to side. Unfortunately, here again it could not be seen what eventually happened to the weed. When they settled down on to the water they did not shake, but separated and swam off together for fifty yards or so. Then he dived; she followed suit after two or three seconds. They came up about twenty-five yards apart, he once more with weed, she once more without it. They swam together, but he dropped the weed when only a couple of feet off, and all they did was to shake for a short time. They then went off fishing, and were lost sight of.

This pair is also interesting in various ways. The "back-to-back" position was never seen in any other birds. Here, too, the pair itself and both the individual birds of the pair had well-marked idiosyncrasies. The very frequent bouts of shaking, the several "flirtations" of the cock, and the fact that the cock brought weeds up three times (the hen not at all) are all worthy of note. The twice-repeated dropping of the weed just before the cock reached the hen is very curious; perhaps the hen's having no weed had something to do with it.

Once more, too, it is seen that all these emotional actions may take place far from the nest, and so without any direct relation to the act of pairing.

**13. April 18.** 2.50-3.35 p.m.

Two birds, one certainly a cock, the other doubtful, were swimming about and fishing, 10 to 30 yards apart. Each frequently went into the Dundreary attitude and barked, apparently at the other, the obvious cock less frequently. Once the doubtful bird dived and came up a dozen yards or so from the other; both advanced a couple of yards, stopped, regarded each other for some moments (rather fiercely, it seemed to me), and then retreated. I watched them for three-quarters of an hour, and their general behaviour was the same throughout, except that they "Dundreared" less frequently as time went on.

I do not understand the relation between these two birds. I think it was a hostile one; possibly they were two cocks on the borders of their respective territories and jealous of their frontier rights.

**14. April 19.** 6.30-6.40 p.m. Close to the reeds.

Here was a curious little "domestic drama":—

A pair was swimming about together, and a solitary hen with a very small ruff was not far off. She was obviously very much wanting some emotional excitement, for she kept on swimming up towards the cock, especially when the other and "rightful" hen was some way off. The lone bird would swim up to within three or four yards, eagerly, yet nervously, then turn and go off as if frightened. The cock was rather indifferent; once or twice he began swimming after her, but never got far. Once he was left mid-way between the two hens, and behaved exactly like the legendary Ass between the two equidistant bundles of hay. He looked first one way, then the other, back and forth, back and forth. At length his mate came a bit nearer, and he at once turned and swam towards her.

At length the cock's mate dived: the "wrong" hen at once dived too, and when she came up found the other hen between herself and the cock. After a minute or so she approached again, and this time all three birds dived several times, and finally the single bird was driven right away.

Throughout, curiously enough, there was no sound, nor any erection of crests, nor any going into Dundreary-position; all three birds stayed always in the normal swimming attitude. Whether the late hour had anything to do with this I cannot say. The diving and driving away, however, showed that there was some very real jealousy aroused.

It is worth noting that the second time his mate dived to drive the strange hen away, the cock joined her, but not the first time.

#### 15. April 20. a.m.

I noticed two birds shaking vigorously. At the close of the bout, a third bird—a hen—came slowly up to the shakers from where she had been resting some twenty yards away. As she came nearer, the cock seemed to look with some hostility at the bird with whom he had just been shaking. This bird, as the event conclusively proved, was only a stranger, and the hen that had been approaching was his rightful mate. The “right” hen then swam at the “wrong” one and drove her away (no flying or diving); then she turned and swam towards the cock. When still three or four feet apart they started shaking, in the excited forward shaking-attitude, with ruffs well up. There were about twenty shakes; as the bout went on the birds lapsed into the ordinary shaking-attitude. The strange hen stayed close by, but after the shaking was over, the cock’s rightful mate swam at her, and there was “confused diving,” eventually “involving” all three birds, and ending in the odd bird being driven off.

The stimulus given to emotional excitement by jealousy is here well brought out; but it is curious that the cock’s true mate, although so close, did not interfere until his bout of shaking with the stranger was over and done with.

### 11. MISCELLANEOUS NOTES.

#### 1. *Fishing.*

The birds may often be seen to pick small objects off the surface of the water, often going on for a considerable time. These objects seem certainly to be eaten, but what they are I do not know. This habit does not appear to have been previously noted.

One bird which I saw fishing by itself for over an hour (a very long time for a Grebe to do anything continuously) had a curious habit of putting its head right down into the water, with bill vertical, till the eyes were just covered. It once stayed like this for a good quarter of a minute, but usually it took its head out after a few seconds, then after a few more seconds put it in again, and so on, all the while swimming slowly forwards. It was apparently looking for prey. I saw it dive while its head was below the surface, but it once dived from the normal position—*i. e.* without any preliminary searching. In other Grebes I have never noticed this habit.

When fishing, they often go along the bank and look for shoals

of small fish, for when they dive for food close in shore one often sees swarms of little silvery fish spring into the air all round.

### 2. *Relations with birds of other species.*

When a Grebe is on the nest, it resents the too close proximity of other birds. One hen that I saw sitting was twice annoyed by Moorhens coming too close; she raised herself from the resting position, bent her neck forward, and definitely (though rather slightly—about to the “half pear-shaped position”) erected her ruff (I am doubtful as to her “ears”). Once she was silent, but once she gave a low rasping note. On this the Moorhens retreated.

This same hen was also roused from her snoozing by the call of a Coot near by; their sleep on the nest must be very light.

Once, on the open water, I saw a hen Tufted Duck happen to come close by a Grebe. The Grebe, strange to say, seemed greatly alarmed, flapped off for some yards, and dived, regaining calm again when the surface was regained at a safe distance.

When neither bird is sitting, the Grebes' nests and platforms are often ascended by other birds. Several times I have seen Moorhens climb on to nests with covered eggs, peck about for food, and swim off. On what was probably a pairing-platform I once or twice saw a pair of Wild Duck, and several times a pair of Shovellers; they were enjoying a comfortable nap!

On one occasion a Mallard was seen on a nest: a Grebe came along with a mouthful of weed for the nest, and at its approach the intruder hastily got off; the Grebe, however, pursued him for three or four yards, before turning and laying the weed on the nest.

### 3. *The Grebe essentially diurnal.*

In the spring of 1911 I had been on the Welsh coast, where there was an abundance of shore-birds. Of these, certainly the Redshank, Sheldrake, and Curlew (and very likely others) seemed to be as wakeful by night as by day, and the special and unmistakable courtship-notes of the first two species were heard all night long, especially on moonlight nights.

My brother and I each slept out a night at the reservoirs to see whether the Grebes behaved in a similar way. During the dark hours, however, there was nothing to be seen or heard of the birds. In the early morning, at the first faint showing of the false dawn, a few Grebes began to call, and various other birds, too, showed signs of activity. Unfortunately, between this and actual sunrise I fell asleep again. My brother, however, watched the whole period without noting anything of interest. Pycraft ('11) finds the same hold good in September. Selous ('01) says that, like many other birds, the Grebe is most active in the first hour or two after it has become light.

The Crested Grebe is thus a purely diurnal species: such birds as Owls and Nightjars are purely nocturnal (or perhaps late-

crepuscular would be more accurate, especially for the Nightjar, who is silent for at least the three or four midnight hours); while in some species, like the Redshank (or the cock Nightingale in spring), periods of activity and rest alternate throughout the twenty-four hours.

#### 4. *Rest and reserve.*

In spite of its being active only during the daylight hours, the Grebe spends many of these resting, in the attitude so well described by Selous as resembling a pork-pie (see Pl. I. fig. 2). This is but one further instance of the principle of reserve that runs through all life. In watching birds two forms of this are especially brought under notice—the reserve of time and the reserve of nervous energy that are present in normally favourable conditions.

In the Grebe, the many hours of the day spent in sleeping, or at least in what Sidis calls the hypnoidal state, represent the time-reserve. These extra hours of sleep, of course, increase the energy-reserve. This latter is, in most birds, got rid of in actions which seem entirely without biological significance—they merely excite pleasure by releasing the energy in bodily movement or in sound: think of the pleasure-flights of gulls in early spring, or of swallow-broods in late summer (here accompanied by twitterings), or the antics of wagtails in fine autumns on the lawns. In the spring, however, the surplus energy of many birds has been seized upon by Sexual Selection, and used up in fighting or in display (*cf.* Wallace's general ideas on the rôle of energy in Sexual Selection, and Howard ('13)). In the Grebe, similarly, it has been diverted into fresh channels through Mutual Selection, and thus pressed more directly into the service of the species.

#### 5. *Powers of learning by experience.*

As an interesting side-light on the psychology of these birds, I will record an incident seen by my brother.

A Grebe had caught a very large fish and was trying to swallow it in the usual way, first throwing its head violently back and then stopping it suddenly, thus jerking the fish (which, of course, is held so that its head was foremost) down the throat. This fish, however, was too big. After a long period of fruitless jerking, the bird was forced to put the fish out into the water. The fish, being still alive, swam off. This was too much for the Grebe, who at once dived, caught it again, and again attempted to swallow it. Naturally it had again to put it out and the whole process was repeated. It attempted to swallow the fish four times; the fifth time it let it swim off as best it could. The whole thing is thus a reflex chain: "See fish—catch fish—try to swallow—no use—put fish out:—See fish . . ." and so on. It did, however, profit by experience, for each time it made rather fewer efforts to swallow it, and at last stopped its fruitless trying altogether.

6. *Calls.*

I give a brief list of the chief calls employed by the Grebe. As we should expect in a bird with such a complex emotional life, different calls are used in different circumstances—we have in them another method of expressing emotions.

(i.) *The groan.*—Typically, a deepish, fairly loud groaning sound, not guttural or rolling; occasionally it was given on a somewhat higher note, and then “rolled” slightly.

This is not a common call: I only heard it coming from birds in the reeds. I do not know with what emotions or actions it is associated.

(ii.) *The bark.*—This is given when one bird is searching for its mate (first stage of Discovery ceremony), or as an indication of hostility towards a bird of another pair; and, I think, on no other occasions: it seems, also, only to be uttered when the bird is in the Dundreary attitude. There are two chief variations:—

(a) A loud, rolling, rather shrill and “trumpeting” bark, several times repeated.

(b) A much less loud bark, not so long, not shrill at all, nor rolling; repeated quite quickly, but only a few times.

(iii.) *The shaking call.*—This is only given during a bout of shaking. I believe the two are always associated (except perhaps at the end of very long bouts). It is especially marked when shaking takes place in the “forward” position.

It consists in a rapid alternation of two sounds on two notes:—a consonantal sound—*k’p* or *t’c*—on the low note, and an indefinite vowel sound about a tone higher.

(iv.) *The “Double Trumpet.”*—This is a very strange-sounding call, generally given from the reeds, often when near the nest. It is somewhat of the same timbre as the love-call of the Tufted Duck, but lower, louder, and more throaty—being, indeed, extremely guttural.

It is composed of two halves, with a slight pause between. The first half is something like *ah* or *aw*, three or four times repeated, and rises very slightly. The second half may be represented thus:—*kwaa-aa-ah*: it sinks rapidly, and is as it were pressed out, being loudest in the middle.

(v.) *The “Dentist-call.”*—I have given it this name as it reminded me irresistibly of that rotating instrument of torture used by dentists for boring. Imagine the biggest burr grinding very stiffly for a few seconds, then suddenly running more freely and whirring for a little. This will give a very good idea of the sound: and this double sound is repeated several times. I have only heard it from the reeds: it often follows the “groan.”

(vi.) *The Owl call.*—This very much resembles the common “*ker-wick*” of the Brown Owl, except that the initial *k* and *w* are not given by the Grebe. It may be repeated, and is often heard. Perhaps it is the simplest, least definitely emotional call-note (recognition-note).

### 7. *Territories.*

For a general review of the subject, see H. Eliot Howard ('13).

Like most (or all) monogamous birds, each pair of Grebes appears to stake out for itself a definite region or territory, from which intruders of the same species are jealously driven off.

The Grebe, however, differs from birds like the Warblers, and from the Kingfisher. Such birds live almost exclusively in their own territory during the whole of the breeding-season, feeding, sleeping, courting, and nesting in it. With the Grebe, on the other hand, the territory (to judge from my own experience and from certain of Selous's observations) is a comparatively small piece of water in the vicinity of the nest, and therefore near the reeds. The open water and the shore, when bare of reeds, is "Common Land," so that almost all the fishing is free to all. And thus, as a matter of observation, nearly all the feeding and nearly all the courtship of the birds takes place on this common ground. This fits in very well with the fact that all the hostilities I have ever seen on open water were apparently always due to sex-jealousy. It is only in respect of nesting, of pairing and the pairing-ceremonies (and probably of sleeping) that the birds restrict themselves to their territories.

So far as the relation of food and territories go, one might draw parallels between birds and man; the affairs of the Warblers would correspond to (present-day) agricultural conditions, the Kingfisher gives us riparian ownership of fisheries, while the free deep-sea fisheries are represented by the common open-water of the Grebe.

### 8. *Swimming Abilities.*

Two feats of skill call for notice. In the first place, I have twice seen birds swimming forwards, in a comparatively straight line, and apparently with intention, while their heads were tucked away under their wings.

In the second place, I have seen a Grebe, when frightened off her nest, dive and swim a good forty yards under water before rising, although the water was so shallow that she made a ripple on the surface all the time, and so overgrown with reeds that the bird's course had to swerve continually round the obstacles.

### 9. *Stretching of Wings.*

Every bird-watcher must be familiar with the habit of Cormorants and Shags, of holding their wings out from the body, apparently for the purpose of sunning them. I have observed this in the Grebe, but curiously enough only in one bird, which acted thus twice in ten minutes. It had been preening itself, and suddenly, raising its anterior end slightly, it stretched its wings horizontally. They were much arched, and showed the

white bars very distinctly. After 15 or 20 seconds, during which I think a little further preening was done, the wings were brought back to the normal position.

## 12. POSTSCRIPT.

Owing to accidental circumstances, it was unfortunately only after the completion of the MS. of this paper that I was able to read Mr. W. P. Pycraft's interesting book on the Courtship of Animals (Pycraft, '13).

As I intend to attack the problem of the relations of Mutual and Sexual Selection in a more general article, it will be unnecessary to discuss his general conclusions here in detail. Let me only say that had I, before writing this paper, read his general discussion of female choice and of the modifications required in Darwin's original Sexual Selection theory, much of my own theoretical conclusions would have been differently expressed, although perhaps not essentially altered.

Let it be particularly noted, however, that Mr. Pycraft himself is careful to point out that Darwin's main conclusions stand firm. As I understand it, the chief modification necessary relates to female choice. Display and ornament do not act on the æsthetic sense of the female, but on her emotional state; they are—using the words in no narrow or unpleasant sense—excitants, aphrodisiacs, serving to raise the female into that state of exaltation and emotion when alone she will be ready to pair. This is brought out most vividly in the nuptial behaviour of the Newts (Pycraft, '13, p. 170). No one, after reading this, can fail to understand not only that the pure Darwinian theory needs modifying, but also the direction in which it must be modified.

But the element of choice does, in another form, remain. In animals such as Birds, where there is a regular pairing-up season, and where, too, the mental processes are already of considerable complexity, it is impossible to doubt but that mating may be, and in some species is, guided by impulse, unanalysable fancies, individual predilection. There, in a rudimentary state, we find that form of "choice"—intuitive, unreasoned, but none the less imperious, and none the less in its results a true choice—which reaches its highest stage of development in the intensely-felt affinities of man and woman—in that condition known as "falling in love," where the whole of the subconscious mental activities become grafted on to the inherited sexual passions, the whole past of the mental organism is summed up in the present, in the intensely real act of choice which chooses one from among thousands and says, whether in words or no, "that one being, and no other, is the being that I desire for my mate."

That a choice of this type can exist in birds is shown by the subject of this memoir. The individual variations in the courtship-actions provide the raw material for preferential mating, and the fact that the birds of a pair often both show some

special variation in the form of action, in itself proves that such preferential mating may and does occur.

The first modification of Darwin's ideas leads to a second—to a modification of the way in which Sexual Selection works. If display is normally an excitant, then there is no "need" for a preponderance of males, nor for actual rivalry between several males. Selection is primarily a matter of level. The female does not choose the "best" out of a bunch of suitors; but those males in which the ornaments and display-habits do not reach a certain standard, will not be able to raise the female's emotional state to the requisite pitch, and so will die without offspring. (This statement as it stands goes too far; it will serve, however, for the time, to show the general idea.)

This primitive condition has been modified in two ways (and on the existence of these two quite distinct lines of development I feel Mr. Pycraft has not laid sufficient stress). In the first place, in polygamous and polyandrous (and perhaps "promiscuous"?) species there may be a rivalry between several males in the presence of the females, as in the Ruff and Prairie Hen.

In the second place, the line of *mutual selection* was started. Whether in origin mutual displays too acted as excitants, it is not yet possible to say until more observations are at hand. That such may be the case, is possible from some observations of my own on the Herring-Gull. At any rate, in specialized forms of this form of courtship, such as that of our Grebe, this excitatory function is completely in abeyance.

With Mr. Pycraft's insistence, first, on the principle of Orthogenesis and its importance for the origin of sexual (and other) forms of ornamentation, and secondly, on the necessity for a psychological point of view in our interpretation of the courtship-phenomena of animals, I am in entire agreement.

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## SCIENTIFIC NAMES OF BIRDS MENTIONED IN THE TEXT.

To save constant reference to birds by both English and scientific names, and to help foreign readers, I append this list.

|                 |  |
|-----------------|--|
| Blue Tit.       | <i>Parus cœruleus</i> L.                   |
| Bustard.        | <i>Otis tarda</i> L.                       |
| Coot.           | <i>Fulica atra</i> L.                      |
| Dabchick.       | <i>Podiceps fluviatilis</i> (Tunst.).      |
| Egret.          | <i>Ardea, Egretta, Herodias, Garzetta.</i> |
| Fulmar Petrel.  | <i>Fulmarus glacialis</i> (L.).            |
| Guillemot.      | <i>Uria troile</i> (L.).                   |
| Heron.          | <i>Ardea.</i>                              |
| Herring-Gull.   | <i>Larus argentatus</i> Gmel.              |
| Kagu.           | <i>Rhinocetus jubatus.</i>                 |
| Mallard.        | <i>Anas boschas</i> L., ♂.                 |
| Moorhen.        | <i>Gallinula chloropus</i> (L.).           |
| Peacock.        | <i>Pavo cristatus</i> L.                   |
| Prairie Hen.    | <i>Tympanuchus americanus.</i>             |
| Razorbill.      | <i>Alca torda</i> L.                       |
| Redshank.       | <i>Totanus calidris</i> (L.).              |
| Shoveller.      | <i>Anas clypeata</i> (L.).                 |
| Snipe.          | <i>Gallinago cœlestis</i> (Frenz.).        |
| Swan (Whooper). | <i>Cygnus musicus</i> Bechst.              |
| Tufted Duck.    | <i>Fuligula cristata</i> (Leach).          |
| Warblers.       | Sylviidæ.                                  |
| Wild Duck.      | <i>Anas boschas</i> L.                     |

## EXPLANATION OF THE PLATES.

[The figures were drawn from my notes and rough sketches by Miss Woodward, to whom I am much indebted for the interest and care she has shown. Taken as a whole, they give a far more graphic and accurate idea of the birds' general appearance and behaviour than any other illustrations of which I know.]

All figures refer to *Podiceps cristatus*.

## PLATE I.

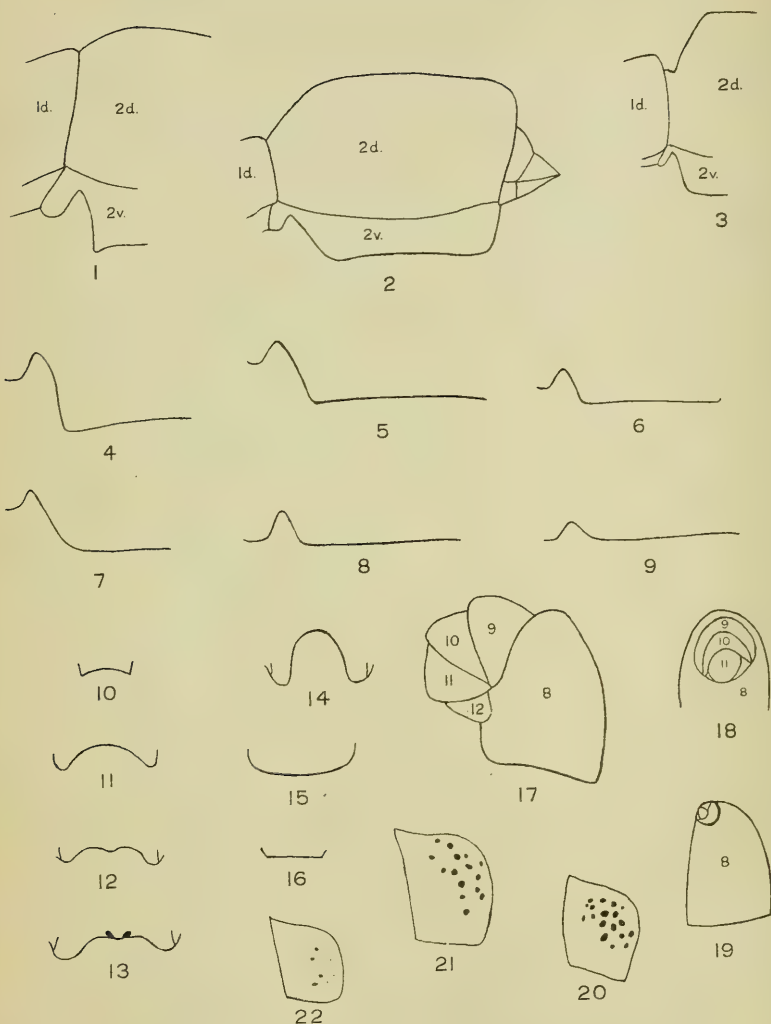
- Fig. 1. Head and neck, showing ruff and ears relaxed.  
 2. Resting attitude. Note the position of the head, and the curve of breast and rump. In most figures these are erroneously represented.  
 3. Search (Dundreary) attitude. Note the ears relaxed, the crest spread longitudinally (sometimes it may touch the water).

- Fig. 4. Head and neck in Shaking-attitude (ears erected vertically, ruff pear-shaped).  
 5. Shaking-attitude from behind. Note the curious shape of the lower part of the neck.  
 6. A pair in the Forward (excited) Shaking-attitude. Note the head bent down, the neck strained forward; the slope of the body and cock of the tail are also very characteristic.  
 7. The Cat-attitude (Display). The general attitude is very well represented. More white should show on the breast; and the dark portion of the wings should be grey. To represent them black lessens the effect of the real black on the crest, which in actual life is the central and most conspicuous part of the picture.  
 8. The Passive Pairing-attitude. Note the strange stiff appearance, the humped back, and the total closure of the crest.

## PLATE II.

- Fig. 9. The "Ghostly Penguin" (attitude on emergence of the diving bird in the Display Ceremony). Note the head bent down, and the forward curve of the top of the neck.  
 10. The same as fig. 9, side-view. Owing to the short time occupied in the action, I cannot myself be sure that all the details in figs. 9 and 10 are accurate. The general appearance, however, is well given.  
 11. A pair shaking. Note the erect necks, and the tails slightly cocked up.  
 12. Display Ceremony: the diving bird just fully emerged. (This is the only figure which is not satisfactory. It gives the positions etc. well, but does not recall reality in the vivid way done by the others.)  
 13. The Penguin Dance. Here again the whole ceremony takes such a short time that I cannot vouch for details; but the general appearance is very well suggested.





R. C. L. Perkins, del.

Bale & Danielsson, L<sup>td</sup> imp.

STRUCTURAL CHARACTERS OF PARALASTOR, SAUSS.

34. On the Species of *Alastor* (*Paralastor*) Sauss. and some other Hymenoptera of the Family Eumenidæ. By R. C. L. PERKINS, M.A., D.Sc., F.Z.S.

[Received April 9, 1914; Read May 19, 1914.]

(Plate I.\*)

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| <i>Abispa meade-waldoensis</i> , sp. n. ....  | 623     |

The name *Paralastor* was given by Saussure to one of the several divisions of the genus *Alastor* which were characterized by him. It includes all the species of the Australian region, except one, *Paralastoroides clotho* Lep., and this differs but little from the other Australian species.

*Paralastor* is a valid genus, and has no close affinity with the non-Australasian forms included in *Alastor*. Its most remarkable character lies in the structure of the antennæ of the male, the peculiarities of which were quite overlooked by Saussure, as they were also in other genera of Eumenidæ, such as *Abispa* and *Pachodynerus*. The antennæ of *Paralastor* ♂ consist always of eight well-developed joints, followed by four, three, or two small, or often very minute, ones. This deficiency in the normal number of joints of the male is always accompanied in both sexes by a thoracic structure, so different from that of the *Alastor* of other countries that the genus is extremely well defined. The thoracic characters have been so clearly stated by Saussure that it is not necessary to repeat them here.

The S. African species *Alastor braunsi* Meade-Waldo, and *Alastor variolosus* Bingham from Ceylon are members of one group, quite distinct from *Paralastor*, having ordinary male antennæ with the normal number of joints (13), as in *Odynerus* and like European *Alastor*. On the other hand, the E. African *Rhynchialastor fuscipennis* M.-W. is more related to the S. American species, such as *A. melanosoma* Sauss., but the clypeus is pointed at the apex and the 2nd ventral segment of the abdomen has a costate sulcature followed by a deep large impression, and is not merely flattened between lateral carinations.

The coloration of the species of *Paralastor* is interesting, in that, like the *Odynerus* of the Hawaiian Islands and elsewhere,

\* For explanation of the Plate see p. 624.

the species form a number of distinctive colour-groups, which are quite different from the groups formed by them when characters of structure are considered. Particularly interesting are the species of the second division of the genus as arranged by me, since several of these closely resemble small species of Australian *Icaria*, social wasps, which are found in the same localities. The resemblance is rendered far more perfect from the fact that in these *Paralastor* the basal abdominal segment is reduced in size and is less wide than usual, so that the abdomen approaches in form that of some of these social wasps.

As to the other division of *Paralastor*, the species not only form colour-groups amongst themselves, but these groups mostly, and perhaps all of them, reproduce the colours and patterns of other genera of solitary wasps, *Odynerus*, *Rhynchium*, and *Abispa*. Even the bees of the genus *Hylaeoides* (Prosoptidæ) are drawn into these colour-groups, and both in these bees and some of the *Odynerus* the resemblance extends beyond the matter of colour, so that certain peculiarities of structure are reproduced in all. I have elsewhere (Ann. & Mag. N. H. (8) ix. 1912, p. 108, *Hylaeoides*, and p. 121, *Abispa*) referred to cases of this structural mimicry combined with mimicry in colour. How great is the resemblance may be judged from Saussure's description of *Alastor fraternus*, of which he says: "Presque identique par la coloration avec les *Odynerus clypeatus* et *concolor*; formes les mêmes," etc.; but this case, naturally, does not compare in interest with that of the bee *Hylaeoides*, where structures identical with those of *Paralastor* are assumed, these structures being unique in that family of bees to which *Hylaeoides* belongs. In the case of the *Odynerus* and other Eumenid genera, where structural and colour mimicry are combined, we are at least dealing with members of a single family, however distinct the genera themselves may be.

All the species of *Paralastor* from Tasmania that I have myself seen, are extremely similar in appearance, with nearly white markings and two very narrow abdominal bands. *Odynerus* of quite similar appearance were taken with these by Mr. R. E. Turner last year.

In N. Queensland, *P. optabilis*, which has a coloration entirely unlike any other Queensland species of its genus, is mark for mark the same as an *Odynerus* occurring with it, and both have similar structural peculiarities.

At Adelaide in S. Australia and in Victoria are numerous species with deep dull orange or red markings, superficially either entirely or nearly resembling one another, though falling into the most diverse structural groups. These species seem to vary in their patterns individually, and it would appear that different species exhibit similar variations of pattern.

Orange-marked species (though found elsewhere) are abundant in Queensland, while W. Australia has a very distinct colour-group, the thorax of the species being largely red, and the basal abdominal segment similarly coloured, while the rest is black. It

is interesting to note that the four members of this last colour-group that are at present known fall each in a totally different group structurally. Of course, W. Australia has species otherwise coloured, which resemble those from other parts of the country.

North Queensland has a number of species remarkable for the ornamentation being nearly confined to the large 2nd abdominal segment, the pattern of this being very distinctive, sometimes ferruginous, sometimes yellow or nearly white.

It is evident that many and perhaps most of the species exhibit considerable variety in colour or pattern of colour, as also in smaller details of structure, but to what extent this is the case, whether as regards individuals from one station or those from separate localities, the material at my disposal is far too limited to decide. This material consists of the British Museum Collection, excluding the actual types of Saussure and Smith (most of which, however, I have examined); of the collection in the Hope Department of Zoology in the Oxford Museum, including types, and of my own collection. The total number of specimens is only 333, although 2000 or more would hardly be adequate for dealing with the genus satisfactorily. Moreover, as six species together account for 101 of the 333 examples, it will be seen that about 90 species are represented very poorly indeed. There is no doubt that great numbers of species and local forms remain to be discovered, and the genus will ultimately prove to be very difficult. Even at present the species are not at all easy, compared with the Hawaiian *Odynerus*, which about equal them in number.

A great deal of the material in the British Museum and at Oxford is very old and often dirty, and has, further, been badly mishandled in the desire to extend the wings.

In *Alastor*, *Odynerus*, and kindred genera, the abdomen should always be kept flat on the ventral surface, and not bent at the suture between the first and second abdominal segments, as is often the case. It should, however, be bent downwards at the petiolar articulation, so as to fully expose the propodeum. If properly mounted in this way, the base of the second ventral segment will be fully exposed and the structure of the segment readily observable. To anyone who has handled many hundreds of species of Eumenidæ, proper preparation of the specimens is of minor consideration, as he will easily make allowance for the retraction or flexure of the second ventral segment, but to one not so circumstanced, the difference in appearance caused by poor preparation may be a source of serious error.

Two species which I have described on single specimens have not the neurulation of *Paralastor*, but of *Odynerus*, the second cubital cell not being petiolate. Whether they are constant in this character or not, remains to be proved. It is in any case a very feeble one, for in some species the petiole of the cell is very much reduced, so that it was quite certain that sometimes, either

as a variation or as a specific character, it would be altogether wanting. The importance placed on small differences in neurulation in Hymenoptera has been much overrated, and there is little to commend these characters, excepting the fact that they are obvious at a glance.

Some described species it is impossible for me to tabulate, as I have never seen specimens of them, and the descriptions, admirable as Saussure's are in general, omit certain important points. Some, not included in the tables, I have referred to subsequently with regard to their probable position. The following may be briefly mentioned here :—

- P. albifrons* Fabr. If the tegulæ have a coarse, deep, and conspicuous puncturation, this species would appear to be extremely closely allied to *P. habilis* and *subhabilis*, but superficially distinct by having only “deux très petits points orangés sur le prothorax” and the apical band of the 2nd abdominal segment semicircularly emarginate, the emargination being much deeper in the other two.
- P. australis* Sauss. This would fall in my table in the group of *P. princeps*, *oloris*, etc. If Saussure's specimen was correctly stated to be a female, the yellow clypeus and front of the scape of the antennæ would distinguish it from the females known to me, which resemble it otherwise in colour, as well as the spot on the mesopleura from either males or females of this section.
- P. clotho* Lep. I know no species with this pattern, except *Alastor unifasciatus* Sm., which lacks the scutellar spots, has dark tegulæ and very dark wings with violet iridescence, and is not an Australian species.
- P. cruentatus* Sauss. I think it is impossible to identify this species without seeing the type.
- P. flaviceps* Sauss. I have included this in my table where it would appear to belong. If the tegulæ are coarsely punctured it is correctly placed. In any case it is distinct superficially from all the species which have an entirely black basal segment by the sulphur-yellow head with a black oval mark on the vertex, enclosing the ocelli.
- P. graeffei* Sauss. This species from Ovalau is unknown to me and not included in my table.
- P. lachesis* Sauss. Not included in my table, as the sculpture of the tegulæ is not indicated in the description. Superficially it resembles *P. orientalis* P.
- P. lateritius* Sauss. I suspect this of being a slight colour-variety of *P. carinatus* Sm.
- P. nautarum* Sauss. Probably tabulated rightly; as it is one of the species with “un tubercle saillant en dessous du deuxième segment,” an emarginate clypeus, and the abdomen all black, except the orange basal segment, it cannot be confused with any other known to me.

- P. smithi* Sauss. I unfortunately failed to examine the type of this species, which is in the British Museum, and I cannot place it in my tables from the description nor identify it with any of those described by me.
- P. hirtiventris* Cameron. I have seen Cameron's ♂ type. It is the largest species of the genus, the tibiæ with long conspicuous hairs beneath. The second ventral segment is greatly raised behind the sulcature, prominent at the top of the truncation medially, and clothed with long erect hairs all over, the following segments densely hairy. The thorax is all black, the 1st and 2nd abdominal segments with wide orange apical bands clothed very conspicuously with erect hairs.

I have to thank the authorities of the British Museum for the loan of their specimens for description. Several of these bore type-labels of Saussure's, but the species were not described by him. I have, except in one instance, adopted the names applied by him to these species. Prof. E. B. Poulton very kindly sent me the whole of the Hope Museum collection of this genus. To Mr. Meade-Waldo I am particularly indebted for examining special structures in some of the British Museum type-specimens, which I had overlooked in the limited time at my disposal there, and for sending me descriptions of some others which I needed to complete this paper.

In the following descriptions the measurements are always taken from the front of the head to the apical margin of the 2nd abdominal segment.

In my description of the 2nd ventral segment I use the adjective "elevatus" as applied to the part which lies behind the transverse *sulcus*, because it is convenient and natural to reverse the insect in examining this segment. Of course in reality the segment is not raised, but produced downwards behind the *sulcus*.

When a species is contained in more than one of the three collections examined by me, the actual type-specimen has always been selected from the British Museum Collection.

The genus *Paralastor* may be divided into two main sections, one of which contains by far the greater number of species and exhibits by far the greater variety of structure. The species of the small division (the *Divisio secunda* of the following table) may be characterized as follows:—

Species semper graciliformes; segmentum primum abdominale conspicue parvum, nunquam fortissime transversum, sed subcampanuliforme, secundo semper, basim versus, utrinque conspicue angustato. Segmentum 2 dorsale basim versus fortissime convexum, ita ut semper (a latere visum) supra segmentum basale fortiter aut fortissime elevatum appareat; secundum ventrale, insecto resupinato, post sulcum suum transversum semper supra partem suam basalem (sive præsulcalem) fortissime

oblique elevatum, elevatione summa media nunquam antice producta aut tuberculiformi. Propodeum (excepto *P. picteti*, cujus propodeum nigrum est, abdominis segmento primo rufo, postice pallide-marginato) colore signatum.

There is no absolute discontinuity between the two sections, and one or two species I have placed in both tables. For the most part, however, the insects of either group are separable at a glance by the characters above given, and since the one or two dubious forms are included in both tables, I do not think there can be the least difficulty in placing any of the known forms.

It is clearly the small size of the basal segment that gives the species in the second division their characteristic superficial appearance, and by this also their resemblance to some of the small Australian species of *Icaria* is made much more perfect.

All species that have not the above characters are necessarily referable to the *Divisio prima*.

### *Divisio prima.*

- Thorax, pronoto excepto, semper totus niger; abdominis segmentum basale aut totum nigrum, aut linea aut fascia subabbreviata, haud ad angulos ipsos laterales extensa, sed ante hos evanescente, decoratum.
- (Clypeus semper emarginatus, et abdominis segmentum 2 dorsale basim versus haud conspicue convexim elevatum) ..... 1
- Thorax sæpe aliter decoratus; segmentum abdominis basale nunquam totum nigrum, sed fascia apicali integra, aut nonnullis in speciebus ex majore parte colore ornatum ..... 16
1. Alæ anteriores totæ, aut fere totæ, nigricantes aut profunde infumatæ et conspicue ubique cæruleo-nitentes; clypeus utrinque carina longa, bene exstante, ad aut post medium extensa, haud munitus.
- (Abdominis segmentum primum totum nigrum) ..... 2
- Alæ anteriores in *A. unifasciato* Sm. solo ubique violaceo-nitentes, quo in casu carinis longis, post medium extensis, clypeus est præditus ..... 4
2. Abdominis segmentum 2 rufo-brunneum aut brunneo-aurantiacum, triangulo elongato, nigro, mediano, a basi post medium segmentum extenso, ornatum ..... *saussurei*, sp. n.
- Abdominis segmentum 2 nigrum, fascia apicali flava, rufescente, aut aurantiaca, haud basim suam utrinque attingente, ornatum ..... 3
3. Femora, trochanteres et tibiæ nigra; fascia segmenti 2 abdominalis antice emarginata ..... *infernalis* Sauss.
- Femora, trochanteres et tibiæ rufescentia; fascia segmenti 2 abdominalis angusta, perpaullo utrinque latior ... *rufipes*, sp. n.
4. Clypeus fortissime emarginatus, emarginatione, ac semicirculus, æque profunda, aut etiam hoc profundiore ..... 5
- Clypeus haud profundissime emarginatus, emarginatione arcum, semicirculo minorem, formante ..... 7
5. Alæ anteriores et posteriores fere æqualiter profunde infuscatæ (parte costali nigriore); abdominis segmentum 2 totum rufo-brunneum, aut brunneo-aurantiacum, margine postico primi angustissime, in parte media, cum secundo concolore ..... *fraternus* Sauss.

- Alæ haud distincte ubique fortiter infumatae, sed ex magna parte hyalinae aut subhyalinae; abdominis segmentum secundum saepius nigro aut fusco colore variegatum; si unicolor est, margo segmenti primi posterior haud coloratus ..... 6
6. Abdominis segmentum 2 ad apicem suum sat late nigrum, parte basali (triangulo mediano parvo excepto) colore albo-flavo ornata, fasciam, profunde angulariter postice excisam, formante ..... *conspicuus*, sp. n.
- Abdominis segmentum 2 totum pallidum, aut macula nigra aut fusca elongata mediana, nonnunquam marginem basalem, nonnunquam apicalem attingente, ornatum, picturatione variabili; color segmenti, ut apparet, testaceo-flavus, aut pallide ferrugineus (an post mortem discolor?) ... *dubiosus*, sp. n.
7. Stigma alarum nigrum aut atro-brunneum; tegulae minutissime punctatae, nonnunquam in disco puncta pauca grossiora ferentes, aut plus minusve laeves, et parce obsoletim punctatae; clypeus aut duabus carinis longis, bene elevatis, conspicue instructus, aut obscurius tricarinatus ... 8
- Stigma alarum pallidum; tegulae grossissime et conspicue, saepe rugosim, punctatae; clypeus carina utrinque conspicua, bene elevata, carens (deflexione tamen clypei laterum marginem acutum nonnunquam formante) nec obscurius tricarinatum. .... 13
8. Alæ anteriores et posteriores atro-infusatae; abdominis segmentum 2 dorsale totum ferrugineum, aut nigrum fascia apicali flava aut aurantiaca ornatum ..... 9
- Alæ haud atræ, anteriores solæ in parte costali atro-infusatae, cæteris partibus hyalinis aut leviter infumatis; abdominis segmentum secundum aliter picturatum ..... 10
9. Alæ haud violaceo-colore conspicue nitentes; segmentum abdominis 2 dorsale totum ferrugineum aut opace aurantiacum ..... *cognatus* Sm.
- Alæ conspicue violaceo-nitentes; segmentum abdominis 2 dorsale fascia apicali tantum ornatum ..... *unifasciatus* Sm.
10. Clypeus utrinque fortiter longitudinaliter carinatus, carinis fortiter et acute elevatis (♀) ..... 11
- Clypeus obscure longitudinaliter tricarinatus, inter carinam medianam et laterales depressus, apice leviter emarginato vix bidentato (♂) ..... 12
11. Abdominis segmentum secundum fascia basali, latissima, pallide flava, postice late emarginata, ornatum ... *conspiciendus*, sp. n.
- Abdominis segmentum 2 pallide flavum, plagam magnam subtriangularem nigram includens ..... *elegans*, sp. n.
12. Segmentum 2 dorsale abdominis subsanguineum, plaga basali nigra (haud ad segmentum medium extensa) notatum; segmentum primum spatio lunulato ejusdem coloris apicali ornatum ..... *tricarinulatus*, sp. n.
13. Abdominis segmentum 2 dorsale ferrugineum aut aurantiacum, totum pallidum, triangulo basali nigro et brevi excepto. .... *tasmaniensis* Sauss.
- Abdominis segmentum 2 dorsale plaga nigra mediana, a basi ad medium aut post medium extensa, ornatum ..... 14
14. Caput sulphureo-flavum, ocellis plaga nigra ovali circumdati. .... *flaviceps* Sauss.
- Caput nigrum, macula utrinque postoculari, et macula interantennali, flavis ..... 15
15. Tegulae nigrae ..... *habilis*, sp. n.
- Tegularum margo exterior pallidus ..... *subhabilis*, sp. n.
16. Thorax totus niger; abdominis segmenta 2 basalia tota ferruginea ..... *apicatus* Sm.
- Species aliter colorata ..... 17

17. Abdominis segmentum 2 dorsale pallide flavum, aut ochraceum, macula nigra basali triangulari ornatum, apice trianguli nigri fere ad medium segmentum extenso, segmentis sequentibus et margine primi posteriore cum secundo fere concoloribus; thorax niger, pronoto solo maculis flavescens ornato. *pallidus*, sp. n. 18
- Species colore præcedenti valde dissimiles ..... 18
18. Pronotum, scutellum fere totum, postscutellum, tegulæ, cum propodei lateribus, ochraceo-flava; abdominis segmentum primum eodem fere colore fasciatum, fascia media quadrato-emarginata; secundum nigrum, apice vix pallescente (♂). *insularis* Sauss. 19
- Species colore præcedenti valde dissimiles ..... 19
19. Abdominis segmentum 2 ventrale post sulcum suum transversum in parte media peroblique aut convexim elevatum, et ibidem haud aut vix ad altitudinem, quam pars sua basalis, majorem surgens; clypeus emarginatus ..... 85
- Abdominis segmentum 2 ventrale post sulcum suum transversum in parte media sæpissime fortissime (aut saltem distincte) supra partem suam basalem elevatum; aut si pars postsulcalis partem præsulcalem (sive basalem) altitudine haud superat, a sulco sat abrupte surgit pars posterior, et clypeus truncatus est ..... 20
20. Abdominis segmentum 2 ventrale, post sulcum suum transversum, tantum ad partis basalis suæ altitudinem elevatum; clypeus semper truncatus ..... 81
- Abdominis segmentum 2 ventrale, post sulcum suum transversum, sæpius fortissime supra partem suam basalem elevatum, aut semper distincte altius quam pars basalis ... 21
21. Clypeus (lateribus deflexis exceptis) usque ad basim perfecte deplanatus (nec concavus sive impressus) et parti frontis interantennali deplanatæ, quam perfectissime, adaptatus; postscutellum simplex, inerme ..... 70
- Clypeus basin versus aut ubique plus minusve convexus aut rare impressus; si usque ad basim deplanatus, postscutellum medium tuberculatum aut spiniferum est ..... 22
22. Clypeus sat fortiter emarginatus, et nonnullis in aspectibus paullo inter dentes laterales prominens, ita ut, plus minusve obscure, quasi tridentatus appareat ..... 63
- Clypeus aliter formatus ..... 23
23. Clypeus carinis acutis duabus elongatis longitudinalibus, bene exstantibus, præditus ..... 62
- Clypeus haud ita carinatus, sed margines deflexi laterales nonnunquam aciem acutam formant ..... 24
24. Postscutellum medium spina brevi aut tuberculo distincte armatum ..... 65
- Postscutellum inerme ..... 25
25. Tegulæ perconspicue grosse punctatæ, marginem versus anteriorem puncta hæc grossa ferentes; clypeus semper emarginatus ..... 52
- Tegulæ sæpe minutissime punctatæ ex parte majore, aut fere læves, puncta majora marginem anteriorem versus conspicua rare ferentes, quo in casu clypeus truncatus est ..... 26
26. Abdominis segmentum 2 dorsale in formam conicam fortissime et abrupte (oblique tamen) elevatum; clypeus truncatus ... 79
- Abdominis segmentum 2 dorsale nonnunquam fortiter convexim elevatum, sed haud vere conico-tuberculatum, aut si conicum, clypeus est emarginatus ..... 27
27. Abdomen fasciis unicoloribus duabus (una in specie compluribus) flavis, sæpissime albido-flavis, rarius læte flavis, ornatum;

- fascia prima plerumque lineari, rarissime circiter partem segmenti dimidiam, desuper aspecta, occupante; fascia secunda haud majorem quam quintam partem segmenti secundi occupante; pronoto antice bimaaculato, maculis a tegulis longissime remotis, propodeo nigro ..... 28
- Abdomen aut aurantiaco, aut rufescente colore fasciatum; aut fascia una aut altera aut ambabus distinctissime bicoloratis; nonnullis in speciebus segmentum primum, desuper aspectum, totum aut fere totum est coloratum, propodeo nonnunquam haud toto nigro, maculis pronotalibus nonnunquam ad tegulas aut fere ad tegulas extensis ..... 34 a
28. Species duabus fasciis abdominalibus ornata ..... 29
- Species unica, fasciis compluribus albido-flavis ornata ..... 33
29. Mesonotum in parte dimidia posteriore aut grosse aut densim et rugose punctatum; frons inter antennis maculata; antennæ ♂ 11-articulatae ..... 30
- Mesonotum in parte posteriore haud grosse punctatum, punctis inter se remotioribus aut irregulariter dispositis; frons inter antennis nigra; antennæ ♂ 12-articulatae ..... 34
30. Anguli laterales pronoti anteriores distincti, evidenter prominuli; mesonotum opacum, et cum scutello ubique quam densissime rugoso-punctatum. (Tegulae flavo-marginatae.)  
*emarginatus* Sauss.
- Anguli laterales pronoti anteriores parum distincti, haud prominentes; mesonoti puncturatio minus densa quam in præcedente, punctis (nonnullis in partibus) inter se distinctis ..... 31
31. Tegulae, ex magna parte aut totae, testaceae, haud flavo-notatae; abdominis segmentum primum postice angustissime lineariter fasciato, fascia ipsa haud vel sparsissime punctata.  
(Abdomen in exemplis recentibus pilis longis ubique vestitum; ♂ segmentum ventrale apicale pilis sat longis erectis vestitum; ad basim suam utrinque pilis densis erectis præditum, his sæpe sub segmento præcedente abditis.) ..... *parca* Sauss.
- Tegulae sæpe flavo-maculatae; abdominis segmentum primum postice minus anguste fasciatum, fascia ipsa punctis multis conspicue prædita ..... 32
32. Abdominis segmentum tertium et sequentia (a latere visa) pilis erectis parce vestita; fascia flava segmenti primi antice media emarginata; ♂ segmentum ventrale abdominis apicale pilis erectis sat longis vestitum; ♀ incognita ..... *lætus*, sp. n.
- Abdominis segmentum tertium et sequentia solum tomentosa; fascia flava primi haud antice emarginata; ♂ segmentum ventrale abdominis apicale pilis brevissimis vestitum; ♀ incognita ..... *frater*, sp. n.
33. Clypeus leviter lateque emarginatus, albo-flavus, macula mediana nigro-signata; mesonotum dense distincteque punctatum, tegulis externe testaceis, postice flavo-notatis; alae parum fortiter infuscatæ (♀) ..... *ordinarius*, sp. n.
34. Abdomen fasciis duabus angustissimis flavo-albis; corpus totum pilis longis vestitum, forma graciliore; tegulae fere nigrae; abdominis segmentum primum haud fortissime transversum; clypeus aut truncatus aut vix evidenter emarginatus; antennæ ♂ 12-articulatae ..... *punctulatus* Sauss.
- 34 a. Clypeus fortiter aut fortissime, levissime aut leviter emarginatus, emarginatus tamen ..... 35
- Clypeus aut recte aut subrotundatim truncatus ..... 73

35. Abdominis segmentum 2 dorsale (lateraliter visum) pilis longioribus erectis, sat numerosis, conspicue vestitum; pronotum antice binotatum, propodeo nigro, puncturatione mesonotali confusa, leviter impressa. (Tegulae testaceae; anguli pronoti humerales parum distincti.) ..... 36
- Abdominis segmentum secundum pilis brevibus erectis sparsim vestitum, aut fere nudum; pronotum nonnullarum specierum ad tegulas aut longe has versus coloratum; propodeo nonnullarum colore signato ..... 37
36. Abdominis segmentum primum fascia distincte bicolorata semper ornatum, fasciae margine anteriore haud aut vix emarginato ..... *vulpinus* Sauss.
- Abdominis segmentum primum fascia saepissime fere unicolore ornatum, fascia ipsa, quam praecedentis, semper latiore, et antice conspicue emarginata ..... *vulpinus excisus*, st. n.
37. Abdominis segmentum secundum nigrum, haud fasciatum ..... 52
- Abdominis segmentum secundum fascia colorata ornatum ..... 38
38. Abdominis segmentum primum et secundum (aut ex his unum) fascia distincte bicolorata ornata, aut segmentum primum, desuper aspectum, fere totum rubricolor est, margine postico flavo ..... 39
- Abdominis nec segmentum primum nec secundum coloribus duobus variegata ..... 43
39. Anguli humerales pronoti anteriores distincte prominentes.  
(Tegularum margo exterior albidus aut flavescens; tibiae posteriores ferrugineae aut rufescentes, macula elongata albida ornatae.) ..... *simulator*, sp. n.
- Anguli humerales pronoti anteriores aut fere recti aut obtusi, haud producti ..... 40
40. Tegulae nitidissimae, perpolitae; parte anteriore excepta, laevissimae, haud subtilissime punctatae ..... 41
- Tegulae in parte exteriori subtilissime punctulatae ..... 42
41. Clypeus ♀ laevis, nitidus, glaber, distincte, remote punctatus; tegulae (ex magna parte) flavescentes aut albidae; mesopleura maculata; tibiae intermediae et posticae longe albido-maculatae, tarsi rufescentibus.
- ♂ tibiis omnibus, metatarsisque intermediis et posterioribus supra albidis ..... *donatus*, sp. n.
- Clypeus ♀ conspicue minute pubescens, apice (quodam in aspectu) elevato, grossius subdensim punctatus; tegulae nigricantes; mesopleura nigra; tibiae posteriores albido-flavo notatae, tarsi nigrescentibus. ♂ ignotus ... *despectus*, sp. n.
42. Abdominis segmentum primum, desuper visum, rubricolor, colore hoc antice nigro-emarginato, postice anguste flavo-marginato; mesonotum profunde, aequaliter, sat grosse punctatum; clypeus (♀) antice distincte marginatus.
- ..... *tricolor*, sp. n.
43. Abdominis segmentum 2 dorsale valde fortiter a basi conico-elevatum; hoc, cum primo, late fasciato, fascia prima partem segmenti (desuper aspecti) maximam occupante, antice triangulariter nigro-emarginata. Maculae pronotales ab angulis posterioribus dorsalibus longe remotae ..... *roseotinctus*, sp. n.
- Abdominis segmentum secundum haud distincte conico-tuberculatum ..... 44
44. Pronotum usque ad angulos dorsales posteriores coloratum ... 45
- Maculae pronotales a tegulis longe remoti ..... 48
45. Segmenta nonnulla abdominis apicalia, et dorsalia et ventralia, nigra ..... 46
- Segmenta abdominalia omnia colorata ..... 47
46. Scutellum sat convexum, quam densissime rugoso-punctatum; thorax post partem pronotalem niger (♂); ♀ incognita.
- ..... *aerophilus*, sp. n.

- Scutellum læve, parum convexum, haud densim ubique punctatum, punctis interstitialibus minutis distinctis; scutellum, postscutellum et propodeum late aurantiaco-ornata ... *placens*, sp. n.
47. Clypeus antice distinctissime marginatus; species magna et robusta ..... *eriurgus* Sauss.
48. Pronotum haud aut indistincte marginatum ad truncationem suam anteriorem, margine acute elevato carens ..... 49  
Pronotum (media parte excepta) fortiter acute marginatum ad truncationem suam anteriorem ..... 50
49. Abdominis segmentum tertium et sequentia, et dorsalia et ventralia, bene colorata, colore cum fascia segmenti secundi fere concolore. Clypeus ♂ et ♀ antice distinctissime elevato-marginatus.  
(Picturatio abdominis segmenti 2 dorsalis pervariabilis; nonnunquam colore rufo aut rufo-aurantiaco fasciam apicalem tantum formante, nonnunquam totum segmentum, triangulo nigro basali excepto, occupante.)  
*argentifrons* Sm.
- Abdominis segmentum tertium et sequentia haud bene colorata, marginibus apicalibus tantum obscure pallidioribus. Clypeus ♂ haud marginatus, quam in præcedente fortius emarginatus; abdominis segmentum primum multo minus fortiter transversum, secundi fascia apicalis haud aut parum ampliata; ♀ incognita ..... *subobscurus*, sp. n.
50. Maculae pronotales magnæ, scutello et postscutello maculatis; abdomen nigrum, fasciis duabus parum latis tantum ornatum, secunda haud conspicue utrinque ampliata, latera versus paulatim latiore (♀) ..... *simplex*, sp. n.
51. Species gracilis et elongata, alis explicatis fere hyalinis; pronotum, tegulae, scutellum, postscutellum, propodeum, et abdominis segmentum primum dorsale (desuper aspectum) rufa, aut ferruginea. Abdominis segmentum primum dorsale angustum, subcampanuliforme, lateribus secundi subparallelis, basim juxta inflexis ..... *minus*, sp. n.
52. Thorax (mesonoto nigro aut tantum bimaculato excepto) et segmentum primum abdominale in aspectu dorsali ubique rufa aut aurantiaca, cæteris segmentis abdominalibus nigris. Species aliter coloratae, abdominis segmento secundo semper colore ornato ..... 54
53. Species parva, angustula, colore rubro ornata, alis hyalinis, parte subcostali per paulo infuscata ..... *imitator*, sp. n.  
Species sat robusta, aurantiaco-decorata, alis infumatis, parte subcostali nigrescente ..... *nautarum* Sauss.
54. Species, quarum propodeum nigrum est, pronoto antice maculato, maculis a tegulis longe separatis ..... 55  
Species, quarum propodeum colore est signatum, pronoti colore ad tegulas aut prope ad tegulas extenso ..... 59
55. Abdominis segmentum secundum postice fere recte aurantiaco-fasciatum, sequentibus nigris.  
(Pronotum antice fere recte truncatum (sive levissime concavum), angulis lateralibus distinctis, bene elevato-marginatum; clypeus levissime emarginatus; abdominis segmentum secundum densissime, grosse et conspicue punctatum.) ..... *debilis*, sp. n.
- Abdominis segmentum secundum postice latissime rufo aut aurantiaco-rufo colore fasciatum, fascia utrinque valde ampliata, plus minus angulariter profunde (nonnunquam profundissime) nigro-emarginata, segmentis sequentibus coloratis ..... 56
56. Abdominis segmentum secundum, latera sua versus, quam densissime grossim rugoso-punctatum ..... 57

- Abdominis segmentum secundum, margines versus laterales, distincte punctatum, scilicet punctis bene separatis ..... 58
57. Abdominis segmenti 2 dorsalis margo posterior (desuper inspectus) utrinque fortiter postice productus, angulis acutis prominentibus conspicue munitus (♂) ..... *eugonias*, sp. n.
- Abdominis segmenti 2 dorsalis margo posterior utrinque distincte angulatus, angulis ipsis per paullo prominentibus (♂).  
*microgonias*, sp. n.
58. Abdominis segmentum primum basisque secundi pulchre pubescentia argentea utrinque ornata, propodei lateribus similiter vestitis; fascia abdominalis segmenti secundi ad, aut paullo ante, medium utrinque producta (♂) ..... *argyrias*, sp. n.
- Abdomen haud pubescentia argentea ornatum; fascia abdominalis segmenti 2 fere ad basim utrinque antice producta (♂) ..... *euclidias*, sp. n.
59. Abdominis segmentum 2 ventrale fortissime post sulcum supra partem basalem suam abrupte elevatum, truncatione summa antice subproducta et prominula, tuberculiformi ..... 60
- Abdominis segmentum 2 ventrale post sulcum transversum distincte, sed haud fortissime, supra partem suam basalem elevatum, truncatione summa haud subangulatim antice producta et tuberculiformi ..... 61
60. Segmentum abdominale tertium cum sequentibus nigrum; species magna (♂) ..... *occidentalis*, sp. n.
- Segmentum tertium et sequentia aurantiaco-ornata; species magnitudine medioeris (♂ ♀) ..... *orientalis*, sp. n.
61. Abdominis segmentum 2 ventrale nigrum, postice aurantiaco-marginatum, post truncationem leviter impressum (♂).  
*solitarius*, sp. n.
- Abdominis segmentum 2 ventrale colore flavo et rufo-brunneo ornatum, nulla parte nigra, post truncationem valde late depressum, ita ut truncatio summa incrassationem elevatam, plerumque curvatam, præbeat (♂) ..... *hilaris*, sp. n.
62. Thorax, pronoto excepto, niger; abdominis segmentum secundum dorsale flavum, colore flavo maculam magnam nigram subtriangularem includente. Postscutellum tuberculatum.  
*maculiventris* SMSS.
- Thoracis pars post-pronotalis flavo-maculata; abdominis segmentum 2 nigrum, postice flavo-fasciatum, fascia nonnunquam utrinque fortiter basim versus producta; postscutellum inerme ..... *bicarinatus*, sp. n.
63. Abdomen fasciis 2 abdominalibus flavis aut sulphureis, angustis, haudquaquam dilatatis, tantum ornatum; pronotum antice et scutellum maculis duabus, pallide flavis, ornata.  
(Antennæ ♂ 12-articulatæ.) ..... *optabilis*, sp. n.
- Picturatio cum colore valde diversa ..... 64
64. Alæ atræ, ubique (in quodam aspectu) violaceo-tinctæ; abdominis segmentum 2 latissime fasciatum, fascia antice angulato-emarginata. Thorax exempli unici totus niger, postscutello tuberculo debili munito (♀) ..... *atripennis*, sp. n.
- Alæ fusco-nitentes (subæneo-micantes); abdominis segmentum 2 fascia apicali aurantiaca, fere simplici, ornatum; thorax, mesonoto excepto, ubique aurantiaco-ornatus, postscutello haud tuberculato (♀) ..... *aureocinctus* Guér.
65. Clypeus profundissime emarginatus, emarginatione multo, quam semicirculus, profundiore, dentem utrinque longum et obtusum formante ..... 69
- Clypeus haud ita emarginatus ..... 66
66. Thorax (mesonoto excepto) ubique rubro-decoratus; abdominis segmentum primum rubrum, basali parte nigra, segmentis cæteris nigris ..... *dentiger*, sp. n.
- Species a præcedente colore valde diversæ ..... 67

67. Species aurantiaco-ornatus; scutellum macula magna trans-  
versa, vix aut haud divisa, ornatum (♂) ..... *infinus*, sp. n.  
Species una aurantiaco-ornata, altera colore flaviore, vix  
aurantiaco, decorata; scutellum maculis duabus, late  
separatis, ornatum (♀) ..... 68
68. Fascia abdominalis prima fere simplex, lata; secunda late  
emarginata, latera versus ante medium segmentum basim  
versus producta; propodeum nigrum (♀) ..... *summus*, sp. n.  
Fascia abdominalis prima antice conspicue emarginata;  
secunda fere simplex, latera versus perpaullo ampliata (♀).  
..... *medius*, sp. n.
69. Mesonotum solum nigrum, partibus cæteris thoracis dorsalibus  
aurantiaco - decoratis; abdominis segmentum secundum  
fascia apicali, vix aut perpaullo latera versus dilatata,  
ornatum ..... *eustomus*, sp. n.  
Thorax totus, duabus maculis pronotalibus exceptis, niger;  
abdominis segmentum 2 fascia latissima, antice emarginata,  
utrinque ante medium segmentum producta, ornatum (♀).  
..... *pseudochromus*, sp. n.
70. Clypeus profundissime emarginatus, emarginatione semicir-  
culum formante, aut semicirculo profundiore; frons capitis  
ordinaria ..... 71  
Clypeus late, leviter emarginatus; frons capitis duabus lineis  
laevibus, curvatis et elevatis, conspicue munita ..... 72
71. Species parva, sed sat robusta; abdominis segmentum 2 dorsale  
fascia, utrinque valde ampliata, ornatum; pronotum solum  
maculatum, thoracis partibus cæteris nigris (♀).  
(Clypeus colore variabilis, aut totus niger aut rufo-  
maculatus.) ..... *vulneratus* Sauss.
- Species magnitudine mediocris; abdominis segmentum secun-  
dum, cum sequentibus, nigrum; thorax, mesonoto excepto,  
rufo-ornatus (♀) ..... *fallax*, sp. n.
72. Species aurantiaco-ornata; abdominis segmentum primum  
fascia lata aurantiaca, haud aut vix emarginata, ornatum;  
scutellum, margine posteriore excepto, aurantiacum (♀).  
..... *brisbanensis*, sp. n.
- Species flavo-ornata; vix aurantiaca; abdominis segmentum  
primum fascia flavescente, antice conspicue emarginata,  
ornatum; scutellum maculis duabus, bene separatis,  
signatum (♀) ..... *mackayensis*, sp. n.
73. Species maxima (14-15 mm. ad apicem seg. 2 abdominalis);  
abdominis segmentis 2 basalibus aurantiaco-fasciatis, fasciis  
haud latis, secunda simplici, haud aut vix latera versus dila-  
tata, segmentis sequentibus nigris. Tibiæ nigrae; posteriores  
macula rufa aut flava signatae; intermediae et anteriores  
(nisi attritæ) pilis longis sparsim vestitæ ..... *princeps*, sp. n.
- Species aut præcedente multo minores, aut colore dissimiles ... 74
74. Segmenta 2 basalia abdominis fasciata, cæteris nigris; species  
graciles plus minusve paralleliformes ..... 75  
Segmenta abdominis complura aut omnia colorata; species  
haud graciles ..... 77
75. Pronotum colore rufo fere ad tegulas decoratum; clypeus ♀  
rufo-maculatum ..... *commutatus*, sp. n.  
Pronotum aut nigrum aut maculis parvis duabus aurantiacis  
aut rufis ornatum; clypeus ♀ niger ..... 76
76. ♂ abdominis segmenta 5 apicalia pilis erectis sat conspicue  
vestita; tibiæ utriusque sexus nigrae, basi et apice nonnun-  
quam pallescentibus.  
(♂ clypeus flavus, ♀ niger.) ..... *suboloris*, sp. n.  
♂ abdominis segmenta apicalia pubescentia minuta depressa  
tantum vestita; tibiæ omnes cum tarsis rufescentes.  
..... *oloris*, sp. n.

77. ♂ ♂ *Clypeus flavus* ..... 78  
 ♀ ♀ *Clypeus totus, aut ex parte magna, niger* ..... 80
78. *Clypeus* in parte sua media longitudinaliter impressus, utrinque carinis subobsoletis (rotundatis nec acute elevatis) parallelis instructus; antennæ (ut opinor) tantum 10-articulatæ, articulis 2 apicalibus minutissimis. Cellula 2 cubitalis haud petiolata (an semper?). Segmentum abdominis ventrale 7 sat fortiter convexum ..... *odyneroides*, sp. n.  
*Clypeus* more solito formatus, convexus; antennæ 12-articulatæ, fortiter clavatæ, articulis 4 ultimis parvis sed distinctis; segmentum abdominis ventrale 7 deplanatum.  
 (Abdominis segmentum 2 dorsale fortiter elevatum pilis-  
 que longis erectis vestitum.) ..... *viduus*, sp. n.
79. Abdomen fasciis duabus, haud utrinque ampliatis, ornatum, prima angustissima, secunda haud lata; clypeus utrinque longitudinaliter flavescens aut albido-flavus. Abdominis segmentum 2 dorsale pilis erectis longioribus vestitum. .... *tuberculatus* Sauss.
80. Tibiæ tarsique rufescentes; cellula 2 cubitalis petiolata.  
 (Color variabilis; abdominis segmentum secundum late ferrugineo- aut aurantiaco-brunneo-fasciatum, fascia nonnunquam basim segmenti utrinque attingente.)  
 ..... *carinatus* Sm. (= *lateritius* Sauss., var.?)
- Tibiæ tarsique nigrescentes, his plus minusve atro-brunneis, articulis nonnullis testaceis; tibiæ posteriores, basim versus, in parte interiore, rufescentes. Cellula 2 cubitalis haud petiolata (an semper?). Segmenta abdominalia fasciis ferrugineis aut brunneo-aurantiacis ornata, fasciis apicalibus, quam basales, pallidioribus.  
 (Nescio quomodo sint variabiles picturatio et alarum neuratio.) ..... *odyneripennis*, sp. n.
81. Abdominis segmentum primum fascia sat lata, unicolore, rubra, antice angulariter nigro-emarginata, ornatum (♀). ..... *mutabilis*, sp. n.  
 Abdominis segmentum primum fascia flava, albido-flava, aut flavo-aurantiaca anguste marginatum, aut fascia latiore, conspue bicolorata, decoratum ..... 82
82. Abdominis segmentum primum fascia apicali unicolore decoratum ..... 83  
 Abdominis segmentum primum fascia conspue bicolor ornatum.
83. Mesopleura tegulas juxta sæpe flavo-notata; abdominis segmentum primum transversim parum evidenter depressum; species evidenter minor:  
 a. Mesopleura flavo-notata, abdominis fasciæ (aut prima) pallide flavescentes aut albido-flavæ (♀). ..... *plebeius*, sp. n.  
 b. Mesopleura haud notata; abdominis fasciæ-flavæ ... var. *a*.  
 Mesopleura haud flavo-notata; abdominis segmentum primum transversim sat conspue depressum; species evidenter major, fasciis abdominalibus aurantiaco-flavis, prima, quam in specie præcedente, latiore et sat copiose punctata (♀).  
 ..... *subplebeius*, sp. n.
84. Species parva, angusta; antennæ ♀ fortiter ♂ fortissime clavatæ, his 12-articulatis, articulis tribus apicalibus unum brevem formantibus ..... *debilitatus*, sp. n.
85. (Hac in sectione maris (ubi mas est cognitus) antennæ tantum 10-articulatæ sunt, articulis duabus apicalibus minimis, intra articulum octavum receptis.)  
 Abdominis segmentum primum, parte nigra excepta, unicolor, aut flavum aut aurantiacum aut subrufum ..... 87  
 Abdominis segmentum primum, parte nigra basali (si color niger adest) excepta, colore rufescente et flavo distincte coloratum ..... 86

86. Clypeus ♂ ♀ late flavus; macula capitis ocellaris ♀ utrinque ad, aut fere ad antennarum insertionem utrinque producta.  
*multicolor*, sp. n.  
 Clypeus ♀ rufescens aut ferrugineus; macula capitis ocellaris antice emarginata, parte utrinque producta ab insertione antennarum longe remota. ♂ mihi incognitus... *brunneus* Sauss.
87. Abdominis segmentum secundum juxta apicem transversim impressum, ita ut incrassatio, distincte subelevata, formetur, incrassatione postice abrupte verticali, haud obliqua, margine apicali deplanato lato. Color niger, rufo-decoratus (♀).  
*anostreptus*, sp. n.  
 Abdominis segmentum secundum juxta apicem plus minus incrassatum, incrassatione haud antice elevata, et postice plus minus oblique truncata; partes coloratae plerumque aurantiacae aut flavae aut plus minus rufo-aurantiacae..... 88
88. Clypeus ♀ aurantiaco-rufus; oculi usque ad clypeum colore marginati; maculi pronotales fere ad angulos dorsales posticos extensi; species nigra, rufo-ornata..... *dyscritias*, sp. n.  
 Clypeus ♀ niger, lateribus deflexis flavescentibus, apice rufescent; oculi haud usque ad clypeum marginati; pronotum antice maculis triangularibus ornatum; species nigra, flavo-ornata..... *xanthochromus*, sp. n.

### Divisio secunda.

1. Thorax et abdomen bicolorata, nigra et rufa sive ferruginea ... 14  
 Corpus nonnulla in parte semper flavo aut albedo aut aurantiaco-flavo colore ornatum, saepe tricoloratum ..... 2
2. Tegulae (parte interiori thoracem juxta excepta) ex magna parte politae, impunctatae aut fere impunctatae, sculptura nulla aut vix videnda, puncta rare hic illic disposita nonnunquam ferentes ..... 3  
 Tegulae plerumque subtilissime sed distinctissime in parte exteriori punctatae, nonnunquam sat copiose et grosse punctatae, aut puncta grossa et minuta intermixta ferentes... 8
3. Abdominis segmentum primum supra rubens, margine postico flavo; propodeum nigrum ..... *picteti* Sauss.  
 Abdominis segmentum primum aliter coloratum; propodeo bicolorato ..... 4
4. Abdominis segmentum secundum postice fascia flavo-aurantiaca lata ornatum, partem, majorem quam quartam, segmenti occupante, ad basim utrinque conspicue aurantiaco-maculatum.  
 (Clypeus truncatus aut parum emarginatus.) . *constrictus*, sp. n.  
 Abdominis segmentum secundum nonnunquam haud fasciatum, aut fascia pallide flava, aut obscuricolore ornatum; si aurantiaco-fasciatum, fascia minus lata est, haud quartam segmenti partem occupans.
5. Color flavus superficiem totam posteriorem segmenti primi occupans, colore nigro, si adest, superficiem declivem solam occupante ..... 6  
 Abdominis segmentum primum fascia apicali tantum ornatum. 7
6. Tegulae ♀ haud flavo-maculatae, feminae et maris punctis nonnullis grossioribus et profundioribus signatae ... *mesochlorus*, sp. n.  
 Tegulae feminae flavo-maculatae, feminae et maris punctis minus grossis et profundis signatae ..... *mesochlorus mesochloroides*, st. n.
7. Abdominis segmentum 2 ventrale medium haud impressum; ♀ clypei apex late leviterque emarginatus; mesonotum duobus lineis elongatis subparallelis ornatum; ♂ incognitus.  
 (Abdominis color atro-brunneus, segmentis fasciis albidoflavis ornatis.) ..... *darwinianus*, sp. n.

Abdominis segmentum 2 ventrale post sulcum transversum conspicue impressum, ita ut truncatio summa rotundatim elevatur (♂).

(a) Thorax nigrum, flavo-notatum ..... *comptus*, sp. n.

(b) Pronotum rufum, flavo-notatum, mesonoto medio rufo.  
*comptus*, var. *rubescens*, n.

8. Abdomen brunneum, rufo-brunneum aut atro-brunneum, et colore albedo aut flavo-albedo variegatum ..... 9

Abdomen nigrum, colore sulphureo, flavo aut aurantiaco variegatum ..... 10

9. Tegulae subtilissime ubique punctatae; puncta nonnulla majora sed levissime impressa adsunt; abdominis segmentum 2 dorsale maculis basalibus carens, aut his minimis ..... *alexandriae*, sp. n.

Tegulae subtilissime punctatae et etiam punctis grossioribus, et, quam in praecedente, majis conspicuis, signatae; abdominis segmentum 2 dorsale maculis duabus, conspicuis, basalibus ornatum ..... *arenicola*, sp. n.

10. Clypeus truncatus aut vix emarginatus; ♂ tegulae fere ubique grosse et conspicue punctatae. ♀ incognita ..... *simillimus*, sp. n.

Clypeus distincte, sed leviter, emarginatus; tegulae minutissime copiose punctatae, punctis grossioribus inter punctula minuta nonnunquam interspersis ..... 11

11. Abdominis segmentum 2 basium fasciae evidenter bicolores, antice aut aurantiacae aut rufescentes, postice flavescences aut albescentes ..... 12

Abdominis segmentum secundum plerumque nigrum, aut postice tantum piceo-marginatum, aut fasciam incompletam habens; primum in aspectu dorsali totum (aut fere totum) flavum, aut aurantiacum, haud bicoloratum ..... 13

12. Femora posteriora ubique aut ex magna parte fulvescentia; species facie sua et forma cum finitimis congruens:

a. Stigma lucide flavescens ..... *synchromus*, sp. n.

b. Stigma obscure flavescens aut atro-suffusum ..... var. *a*.

Femora posteriora nigricantia, apicibus plus minus rufescentibus; species elongata, angustissima, abdominis segmento secundo plus, quam solito, elongato et angusto.

(Stigma atro-brunneum aut nigrescens.) ..... *leptias*, sp. n.

13. Pronotum ♂ totum flavum aut subaurantiacum; alarum stigma atrum.

(Abdominis segmentum primum supra aurantiaco-flavum, secundum fascia imperfecta apicali, duabusque maculis parvis subbasalibus, vix conspicuis, ornatum; antenarum flagellum nigrum, apice extremo rufescente. Picturatio segmenti 2 abdominis an constans?) ♂.

*ignotus*, sp. n.

Pronotum ♂ et ♀ haud totum flavum, nonnunquam antice flavo-notatum; alarum stigma lucide flavum.

(Abdominis segmentum primum supra flavum, secundum nonnunquam totum nigrum aut margine apicali piceo aut rufescente; pronotum colore variabilis, supra rufum aut nigrum, aut rufo-marginatum, nonnunquam antice ornatum maculis duabus distinctis flavis.) ... *icarioides*, sp. n.

14. Tegulae ubique copiose, subtilissime punctatae; species major.  
*mimus*.

Tegulae conspicue grosse punctatae, inter puncta nitidae, punctulis minutis, vix aut haud discernendis ..... *imitator*.

## 1. PARALASTOR (Paralastoroides) CLOTHO Lep.

Distinct from all other species by the suture of the first abdominal segment and by the coloration. I have not seen this species, and I do not know whether Saussure saw more than a single example. He says that the suture is "more or less distinct."

*Hab.* Australia.

## 2. PARALASTOR SAUSSUREI, sp. n.

♀. Nigra, fronte interantennali rufo-punctata, capitis vertice utrinque minute flavo-notato; abdominis segmento secundo, triangulo elongato nigro mediano excepto, cum sequentibus, ferrugineo, aut plus minus aurantiaco. Clypeus nitidus, haud densim, sed plus minus strigose, punctatus, apice distincte, levius emarginato. Frons capitis grosse et distincte punctata, linea lævi, semicirculari, ocellum anteriorem includente, instructa. Capitis vertex et thorax densissime rugoso-punctati, postscutello medio elevatulo, sive tuberculato, et, cum propodeo, opaco et multo, quam scutellum, subtilius sculpturato. Tegulæ fortiter conspicue punctatæ. Abdominis segmentum primum, pars secundi dimidia basalis, partes frontis capitis orbitales, et basis et latera flexa clypei, albido-tomentosa, partibus abdominis cæteris aureo-tomentosis. Alæ superiores fortiter infuscatæ, et cæruleo-nitentes. Segmentum abdominis 2 ventrale post sulcum valde fortiter elevatum, elevatione summa prominente. Long. a fronte usque ad apicem segmenti 2 abdominis 15 mm.

*Hab.* North Queensland (*Dodd*).

## 3. PARALASTOR INFERNALIS Sauss.

The band of the second abdominal segment varies in colour from pale orange-yellow to deeper orange, and is sometimes angulately sometimes roundly emarginate. The facial markings of the male vary, the clypeus sometimes being wholly yellow, sometimes only yellow basally, with intermediate conditions. The *sinus* of the eyes is sometimes yellow, the scape in front and a medio-frontal spot probably always so. The pronotum is usually spotted with yellow, more rarely black. Three apical joints of the antennæ small, but distinct. Tegulæ with conspicuous, deep, coarse punctures.

*Hab.* Cairns (N. Queensland) and Port Darwin. Twenty-four examples examined.

## 4. PARALASTOR RUFIPES, sp. n.

Agrees generally in form and in sculpture with *P. infernalis*, but is at once distinguished by the red legs and the narrower apical band of the second abdominal segment, which is only a little dilated at the extreme sides. The postscutellum is without the distinct tubercle of *infernalis* ♀, in which species it may be

obscure in the male, but is well developed in the other sex. Size of *infernalis*.

*Hab.* North Queensland (*Dodd*), 1 ♀.

# 5. PARALASTOR FRATERNUS Sauss.

The male has the clypeus (at least for the most part), the frontal spot, and the front of the scape of the antennæ orange or yellowish orange. The tegulæ are for the most part very minutely punctured and clothed with very short hairs or tomentum.

*Hab.* The single male in the Oxford Museum is from New South Wales, the female type in the British Museum has no special locality assigned to it.

# 6. PARALASTOR CONSPICUUS, sp. n.

♂. Niger; clypeus, macula elongata frontalis huic adjuncta, articulus antennarum primus antice, maculæque 2 pronotales pallide flava, aut albido-flavescentia. Abdominis segmentum secundum fascia lata pallida basali, postice profunde triangulariter emarginata, et antice plus minus nigro-emarginata, ornatum. Clypeus profundissime emarginatus. Frons capitis ante ocellum anteriorem grosse punctata, punctis inter se distinctis. Anguli pronotales prominuli. Mesonotum sat grosse et distincte punctatum, exemplorum recentium dense nigro-tomentosum, pilisque erectis brevioribus subpallidis vestitum. Scutellum tuberculo prominente munitum, propodeo antice grosse punctato. Tegulæ dense et minutissime ex parte majore punctatæ, punctis magnis nonnullis præsentibus. Abdominis segmentum primum fortiter crebre punctatum, punctis sæpe sub tomento denso abditis; segmentum 2 ventrale post sulcum valde fortiter elevatum, elevatione summa prominente; segmentum 7 ventrale pilis erectis minus brevibus vestitum. Antennarum articuli 3 ultimi minimi. Alæ, costali parte excepta, hyalinæ. Long. 11-12 mm.

*Hab.* North Queensland, Cairns district (*Dodd*). Five examples.

The sculpture of the tegulæ, as in *fraternus*, is quite different from that of *P. infernalis* and its allies, the coarse punctures being altogether confined to their inner half (or almost so), the outer part bearing the very fine puncturation.

# 7. PARALASTOR DUBIOSUS, sp. n.

♂. Hardly differs from *P. conspicua* in structure, and is probably only a race of that species. The second abdominal segment is entirely pale, or has a more or less extensive median longitudinal dark marking. The silvery tomentum, that fills the ocular sinus and extends down over the deflexed sides of the clypeus, is more dense and conspicuous and the sculpture of the latter beneath it is somewhat changed in accordance.

This form varies much in detail of colouring, as shown partly in the table of species above. In one example the pronotal spots

are extremely small, while in another they form a broad band, slightly interrupted in the middle.

*Hab.* Queensland, Mackay (*Turner*), 5 ♂; Queensland, from E. Saunders's collection, 2 ♂.

#### 8. PARALASTOR COGNATUS Sm.

This species is entirely distinct from and not closely allied to *P. fraternus*, which it resembles in colour, and of which Smith thought it might be the male. Its comparatively slightly emarginate, bicarinate clypeus distinguishes it at once.

*Hab.* Doro (*Wallace*); type in the Oxford Museum.

#### 9. PARALASTOR UNIFASCIATUS Sm.

Clypeus formed as in *P. cognatus*; the tegulæ shining, with the minute puncturation not, or barely at all, discernible, whereas in *cognatus* their surface is nearly dull, and there is a copious though excessively fine puncturation.

*Hab.* Aru (*Wallace*); type in the Oxford Museum.

#### 10. PARALASTOR CONSPICIENDUS, sp. n.

♀. Nigra; clypei pars basalis et macula interantennalis, nonnunquam sinus ocularis, macula magna utrinque postorbitalis, pronoti margo anterior late, fasciaque lata basalis segmenti secundi abdominalis, postice emarginata, flava aut albido-flava. Clypeus late lunulato-emarginatus, utrinque carina, bene elevata, acute munitus. Frons capitis dense aureo-tomentosa, distincte fortiter punctatus, tomento remoto. Anguli pronotales distincti, haud prominuli. Mesonotum tomentosum, et pilis erectis sat crebre vestitum, postscutello haud evidenter tuberculato. Tegulæ, marginem exteriorem versus, minutissime punctulatæ, ibique haud aliter punctatæ. Alæ, costali parte atro-fusca excepta, fere hyalinæ. Abdominis segmentum 2 ventrale fortissime abrupte supra sulcum elevatum, elevatione summa antice prominula. Long. 12–13 mm.

*Hab.* Queensland, Inkerman, near Townsville (*Stalker*), 1 ♀; Townsville, 1 ♀ (*Dodd*); Queensland, 1 ♀, from E. Saunders. All in the British Museum Collection.

#### 11. PARALASTOR ELEGANS, sp. n.

♀. Colore et picturatione *P. maculiventris* Sauss. (Et. Masar. et Suppl. pl. xvi. f. 3).

This species differs from Saussure's description of *P. maculiventris* only as follows:—The clypeal emargination between the teeth is not straight, but slightly rounded; there is only a yellow spot on the inner orbits, the head is very densely clothed with golden tomentum, not blackish. The fascia of the first abdominal segment is incomplete, failing before the lateral angles.

The clypeus has two very strongly raised longitudinal carinae, not mentioned by Saussure, but which, as Mr. Meade-Waldo has kindly informed me, are present in the type, the face of which is asymmetrical or somewhat deformed. In most respects *P. elegans* resembles *P. conspiciendus*, apart from the quite different colour-pattern, but the clypeus is much shorter and the propodeum shorter and more rounded, less quadrate.

*Hab.* N. Queensland (*F. P. Dodd*), 2 ♀.

## 12. *PARALASTOR TRICARINULATUS*, sp. n.

♂. Niger, clypeo, maculaque elongata interantennali, huic adjuncta, flavis, macula parva verticis postoculari utrinque aurantiaca. Abdominis segmentum primum spatio lunulato apicali rufo-decoratum, secundum ferrugineo-rufum, macula basali, haud ad medium segmentum extensa, nigra, segmentis sequentibus cum tibiis tarsisque aurantiacis aut ferrugineis.

Clypeus leviter emarginatus, apice lato, anguste nigro-marginato, evidenter, sed parum acute, longitudinaliter 3-carinatus. Frons capitis rugoso-punctata. Pronoti truncatio vix marginata. Mesonotum grosse et rugose punctatum. Scutellum postice conspicue foveatum. Postscutellum medium subproductum sive subtuberculatum. Abdominis segmentum primum transversim subconspicue impressum, puncturatione sua, quam mesonotali, minus grossa; segmentum 2 ventrale post sulcum abrupte fortiter elevatum, elevatione summa paullo rotundatim prominula, grossim et copiose punctatum; segmentum 7 ventrale pilis erectis sat longis conspicue vestitum, medium longitudinaliter sulcatum. Alae, costali parte excepta, subhyalinae. Long. 13-14 mm.

*Hab.* Victoria (*C. French*), 1 ♂.

## 13. *PARALASTOR TASMANIENSIS* Sauss.

This species was described by Saussure from a headless male, and is said by him to inhabit Tasmania, but I have only seen Queensland examples.

In the male the clypeus, medio-frontal spot, and front of the scape of the antennae and the postocular spots of the vertex are yellow, the latter sometimes redder or orange. In the female the apical portion of the clypeus is black, the rest orange or ferruginous brown. The scape of the antennae black or largely ferruginous or reddish brown in front. The tegulae are very coarsely punctured, the punctures extending to (or almost to) the outer margin. The apical ventral segment of the male is wide and widely impressed, and bears only very short hairs, as do the preceding segments.

*Hab.* Queensland, Brisbane; in Oct., Jan., Dec., and March (*Hacker*). I suspect that the locality (Tasmania) given by Saussure is erroneous.

14. *PARALASTOR HABILIS*, sp. n.

Abdomen nigrum, segmento secundo pallide flavo, macula magna subtriangulari nigra, ad aut post medium segmentum extensa, signato. ♂ clypeus, macula interantennalis, articulus antennarum primus antice, maculæ parvæ verticis postoculares, maculæ pronotales (nonnunquam fasciam fere integram formantes), pallide flava; ♀ clypeus antice niger, postice aurantiacus; antennarum articulus primus (basi extrema pallida excepta) niger. Alæ hyalinæ, costali parte infuscata, plus minus flavescente. Tarsi posteriores, articulo ultimo excepto, nigri aut atro-fusci; tibiæ aut nigricantes aut rufescentes.

Clypeus distincte, nec profunde emarginatus; frons grosse punctata. Mesonotum, quam densissime, rugoso-punctatum, parum dense pilosum; tegulis nigris, grosse usque ad marginem exteriorem punctatis; postcutellum haud aut vix tuberculatum. Abdominis segmentum primum pernigrum, dense punctatum, inter puncta quasi subtilissime granulatum, secundi pars nigra similiter sculpturata, sed remote punctata; segmentum 2 ventrale post sulcum fortissime abrupte elevatum, elevatione summa prominula; septimum segmentum ♂ ventrale latum, lateque impressum, parum conspicue pilosum, pubescentia brevi vestitum.

Long. 11–13 mm.

*Hab.* North Queensland (*Dodd*); 2 ♂, 1 ♀.

15. *PARALASTOR SUBHABILIS*, sp. n.

Præcedenti simillimus, ut apparet, paullo gracilior, alarum parte costali magis flavescente, et ibidem venis pallidioribus. Tarsi posteriores ubique, aut ex majore parte, pallidi. Tegulæ, marginem exteriorem versus, pallidæ. Segmentum tertium abdominale plerumque flavo-marginatum, aut plus minusve pallidum, rare nigricans, sequentibus segmentis etiam sæpe pallidis.

Possibly only a race of the preceding, but superficially quite distinct. The pattern of the second abdominal segment is different from that of *habilis*, the black median marking narrower and not of the same subtriangular form. Unless it has become changed *post mortem*, the ground-colour is also different, the yellow more ochreous, or in some examples approaching orange, not pale clear yellow or whitish yellow. The colour of the clypeus in the female is not constant; sometimes it is nearly entirely yellow, sometimes black on the apical part.

*Hab.* Queensland, Mackay, 6 examples (*Turner*); Queensland, 1 ♂ from E. Saunders's collection.

16. *PARALASTOR FLAVICEPS* Sauss.

I have not examined the type of this species, but should the tegulæ have a very coarse puncturation extending to the outer margin, then it would be placed in my table next to *habilis* and

*subhabilis*, being easily distinguished by its "tête jaune de soufre ; sur le vertex un ovale noir, qui enveloppe les ocelles" (Saussure). In any case this character of coloration will distinguish it from any other of the species that have the first abdominal segment wholly black.

*Hab.* Australia.

#### 17. PARALASTOR ALBIFRONS Fabr.

I have not examined the type of this species, but Mr. Meade-Waldo has very kindly examined it for me, as to certain structural points, from which I infer it should be placed next to *P. habilis*. In fact, I do not feel sure that the latter may not be a variety or race of the Fabrician species.

*Hab.* Australia (Banks collection).

#### 18. PARALASTOR APICATUS Sm.

The type specimen is from Aru. Examples from Papua (*Odynerus lorentzi* Cam.) are at the most slight colour-varieties, quite unworthy of a special name. The tegulae are punctured on their inner portion, smooth and polished outwardly; the second abdominal segment seen in profile rises up strongly above the level of the first; ventrally, it rises up strongly, but rather obliquely, from the transverse sulcus, and the truncation is not at all prominent or produced forwards at its highest point.

*Hab.* Aru (Wallace), type in the British Museum and 1 ♂ in the Oxford Museum. I have seen several examples from New Guinea.

#### 19. PARALASTOR PALLIDUS, sp. n.

♀. Nigra, clypeo flavo-bimaculato, aut macula curvata basali ornato. Frons interantennalis flavo-maculata; maculae pronotales flavescentes. Tegulae externe flavescentes aut rufo-flavae. Abdominis segmentum secundum ochraceo-flavum, macula triangulari basali signatum, sequentibus similiter pallide coloratis, margine etiam primi postico pallide fasciato, fascia hac media emarginata. Femorum apices, tibiae, tarsique rufescentia. Alae subhyalinae, parte costali infuscata. Clypeus nitidus, irregulariter punctatus, apice distincte, nec profunde, emarginato, margine elevato. Mesonotum densissime punctatum, postscutello inermi. Abdominis segmentum primum obscurius punctatum, secundum ventrale fortissime post sulcum abrupte elevatum, elevatione summa prominente. Tegulae ex magna parte dense distinctissime et subtilissime punctatae.

Unlike any other species superficially. The second dorsal segment is only a little more than ordinarily convex on its basal portion.

*Hab.* Queensland (E. Saunders's collection), 1 ♀; Mackay (Turner), 1 ♀.

20. *PARALASTOR INSULARIS* Sauss.

Unlike any other species superficially, the second abdominal segment black, with the extreme apex only indistinctly pale.

*Hab.* Australia, Swan River; 1 ♂.

21. *PARALASTOR TUBERCULATUS* Sauss. (Pl. I. fig. 3.)

A very distinct species, of which I have seen six females, four in the British Museum Collection and two in the Oxford Museum. This species should be removed from this position and placed next to *P. odyneroideus* (no. 67).

*Hab.* Tasmania; Adelaide; Victoria (*French*). In the latter locality the abdominal bands are deeper yellow, in one example more orange-coloured.

22. *PARALASTOR EMARGINATUS* Sauss.

*Hab.* Tasmania, 1 ♀ in the Oxford Museum; Eaglehawk Neck, S.E. Tasmania, Feb. 12th–March 3rd, 1913, 1 ♀ (*Turner*).

23. *PARALASTOR PARCA* Sauss. (Pl. I. fig. 1.)

In one or two females the clypeus is quite truncate at the apex, and others are intermediate between these and those in which it is quite distinctly, though always shallowly, emarginate.

*Hab.* Tasmania, Franklin; Mt. Wellington and Eaglehawk Neck (*Turner*); Victoria (*French*).

24. *PARALASTOR LETUS*, sp. n.

♂. Niger, clypeo, antennarum articulo primo antice, macula interantennali, duabusque postocularibus, flavis. Pronotum, scutellum et nonnunquam postscutellum, flavo-bimaculata. Mesopleura sub tegulis flavo-notata, his ex magna parte rufescentibus, et nonnunquam flavo-notatis. Abdominis segmenta 2 basalia fascia flava apicali ornata, fascia prima media levius emarginata, secunda simplici, haud lata. Tibiæ tarsique rufescentes. Alæ distincte infuscatæ. Clypeus distincte, nec profunde, emarginatus, pilis pallidis ubique vestitus. Frons capitis dense rugoso-punctata, capite pilis longis vestito. Mesonotum dense punctatum, postscutello inermi; propodei lateribus rotundatis. Abdominis segmentum primum fortiter transversum, parte apicali excepta rugosissime puncturatum; segmentum secundum dorsale basim versus mediocriter convexum, pilis erectis longioribus parce vestitum; secundum ventrale fortissime et abrupte post sulcum elevatum, elevatione summa prominente; segmentum apicale ventrale pilis erectis sat longis vestitum, haud distincte depressum. Long. 9–10 mm.

*Hab.* Fremantle, Australia (British Museum), 2 ♂.

25. *PARALASTOR FRATER*, sp. n.

♂. Niger, capite thoraceque ut in *P. læto*, maculatis. Abdominis fascia prima et secunda fere æqualiter latæ, simplices;

postscutellum nigrum. A *P. læto* segmento tertio dorsali cum sequentibus pilis nullis erectis vestito, segmento 7 ventrali, cum præcedentibus, pilis erectis tantum brevissimis vestito, facile distinguendus. Tegulæ minutissime punctatæ. Abdominis segmentum primum latissimum et cum secundo nigerrimum.

Certainly distinct from the preceding by the differently clothed apical male ventral segment—a very important character. In both the tegulæ are for the most part feebly and very minutely punctate, the punctures feebly impressed.

*Hab.* Albany (*Brewer*); 1 ♂ in the Oxford Museum.

## 26. PARALASTOR ORDINARIUS, sp. n.

♀. Nigra, clypeo albedo-flavo, macula discali nigra; macula interantennalis, una utrinque postocularis, et duæ pronotales, pallide flavæ. Tegulæ nigricantes, in parte exteriori testaceæ, postice flavo-notatæ. Abdominis segmentum primum postice albedo-flavo-fasciatum, fascia utrinque paullo dilatata; segmenta sequentia simpliciter (nec late) fasciata. Tibiæ tarsique rufescentes. Clypeus latus, brevior, apice late et levissime emarginatus. Frons capitis crebre punctata. Mesonotum dense, minus grosse punctatum, postscutello inermi. Propodei latera fere æqualiter rotundata. Tegulæ ex parte magna lævissimæ, politæ, impunctatæ. Abdominis segmentum primum subcrebre punctatum, fascia pallida apicali puncta multa ferente. Abdominis segmentum secundum dorsale basin versus subfortiter convexum, ventrale, post sulcum, fortiter elevatum, elevatione summa haud prominente. Alæ subhyalinæ, parte costali magis infuscata, stigmate medio pallescente. Long. 8.5 mm.

A rather commonplace species, chiefly noticeable as having several pale abdominal bands.

*Hab.* Victoria, Wimmera (*coll. Froggatt*), 1 ♀.

## 27. PARALASTOR PUNCTULATUS Sauss. (Pl. I. fig. 17.)

(♂ = *P. albocinctus* Sm.? ♀, var. = *similis* Sauss.?)

In this species the apex of the clypeus is not always quite truncate, but is sometimes very faintly concave or has the margin a little sinuate. The basal abdominal segment is less strongly transverse than in many of the allied species. It is certainly variable both in small details of colour and structure, and I believe that *P. albocinctus* Sm. is only a male of this species, and *similis* Sauss. a slight variety. Saussurè, in his first description of the latter, says that the second ventral segment of the abdomen is “sans tubercule,” and in his supplement he gives the presence or absence of a tubercle as the only distinctive character between the two forms. As in other species I have found that the truncation of the segment is sometimes more evidently raised or produced in some examples than in others, this minute distinction seems hardly sufficient.

The male of *punctulatus* is abundantly distinct from any of

the similar forms described by Saussure by its 12-jointed (not 11-jointed) antennæ.

*Hab.* Tasmania, Mt. Wellington and Eaglehawk Neck, Jan., Feb., and March, 1913 (*Turner*); Hobart; Mt. Kosciusko, 6000 ft., N.S.W. (*Waterhouse*).

28. *PARALASTOR OPTABILIS*\*, sp. n. (Pl. I. fig. 12.)

Picturatio capitis, thoracis et abdominis, cum *P. fratris* et *P. leti* picturatione congruens. Species robusta, alis infuscatis. Clypeus ♀ medius niger. Clypeus distincte dentato-emarginatus, margine apicali inter dentes laterales medio leviter rotundato, sive paullo producto, quasi tridentato. Caput cum thorace sat dense pilis longis vestitum. Anguli pronotales parum distincti. Mesonotum tomentosum, punctis sæpe plus minus tomento obscuratis, postice haud dense (sc. irregulariter) punctatum, postscutello rotundato, inermi. Abdominis segmenta 2 basalia tomento nigerrima, puncturatione sæpe plus minus abdita, sive obscurata; primum fortissime transversum, secundum pilis erectis crebre ubique vestitum; fasciæ abdominales minus latæ, fere rectæ. Abdominis segmentum 2 ventrale fortiter abrupte post sulcum elevatum, elevatione summa prominente; segmentum ventrale ♂ apicale, æque ac præcedentia, perconspicue et dense pilis erectis vestitum. Antennæ ♂ 12-articulatæ. Tibiæ tarsique rufescentes aut testacei, plus minusve (præsertim in ♂) flavo-notati. Femora anteriora et intermedia ♂ flavo-notata, his in ♀ etiam flavo-notatis. Long. 12 (♂)–14 (♀) mm.

*Hab.* North Queensland (*Dodd*).

29. *PARALASTOR VULPINUS* Sauss.

In its typical form this species is distinct to the naked eye by its narrow first abdominal fascia, which, like the second, is pale yellow posteriorly and orange-brown or brown in front, and its robust form—the latter character distinguishing it from other species which have similarly bicolorous fasciæ. The first abdominal band becomes narrower towards the sides.

Other specimens often show little or no trace of the bicoloration of the fasciæ, which are often orange; the first is then excised or emarginate in the middle, so that it is notably widened on either side. This form may, with larger and better material, prove to be distinct; but I can see no satisfactory structural difference. It may be known as *P. vulpinus* st. *excisus*, n.

The well-clothed second dorsal segment of the abdomen, in well-preserved examples, is characteristic of both forms. The apical ventral segment of the male, if fully exerted, bears at its base a remarkable tuft of dense erect hairs, but these may be withdrawn beneath the sixth segment. Similar tufts occur in *P. simulator*, which is evidently allied to *vulpinus*. The antennæ of the male are 11-jointed.

\* This species should be placed next to *P. aureocinctus* and *atripennis*, as in the table.

I have seen seven examples of *P. vulpinus* and ten of the race *excisus*; most of them are in bad condition.

*Hab.* Typical form: Adelaide, 1 ♀, Oxford Museum, and 1 ♀, British Museum; Victoria (*French*), 1 ♀; Croydon, 1 ♂ (*Froggatt*); the rest without special locality. Race *excisus*: Pt. Stephen, 1 small ♀; Melbourne (*French*), 1 ♀; Mittagong, N.S.W., 1 ♀; Cumberland, N.S.W. (*Turner*), 1 ♀; Woodford, 1 ♀.

### 30. PARALASTOR SIMULATOR, sp. n.

Picturatio thoracis et abdominis picturationi *P. vulpini* fere similis; mesopleura sæpissime nigra, innotata; scutellum nunquam bimaclatum; clypeus ♀ macula magna curvata basali ornatus, aut hac bipartita. Tibiæ tarsique ferruginei; tibiæ posteriores linea albida ornatae; alæ hyalinae costali parte sola distincte infuscata. Tegulae nitidae aut subnitidae, flavo-marginatae, aut albido-marginatae, plus minusve subtilissime punctatae. Clypeus leviter aut levissime emarginatus, ♀ nitidus, parvissime distincte punctatus, inter puncta hæc majora subtilissime distincte punctulatus. Frons capitis dense punctata. Anguli pronotales distincte prominentes. Caput cum thorace pilis crebre vestitum. Mesonotum et scutellum crebre, plus minus grosse, punctata, scutello inermi. Abdominis segmentum primum fortissime transversum; secundum dorsale (præcipue maris) fortiter supra primum convexim elevatum, ventrale fortiter post sulcum elevatum, elevatione obtusa, parum prominente; segmenta sequentia ventralia ♂ brevissime pubescentia. Antennæ ♂ 11-articulatae, articulis 3 ultimis minutissimis. Long. 6·5–9·5 mm.

*Hab.* Adelaide, 2 ♂; Victoria (*French*), 1 ♀; 2 ♂ and 1 ♀ without special locality.

### 31. PARALASTOR PUSILLUS SAUSS.

This species is of the same general appearance and structure as *P. simulator*, but should easily be distinguished by the prothoracic angles being indistinct or not at all produced and the second ventral segment having the top of the truncation in the middle produced into a spiniform tubercle. No mention is made of a white or yellow margin to the tegulae, nor of the conspicuous white or yellow line on the hind tibiæ.

The examples that I have before me from the British Museum and Oxford, named *pusillus*, are partly *P. simulator* and partly other species.

*Hab.* "La Nouvelle-Galles du Sud" (*coll. F. Smith*).

### 32. PARALASTOR DONATUS, sp. n.

Colore *P. simulatori* fere assimilis. Abdomen fasciis duabus bicoloratis ornatum, secunda latera versus ampliata. Clypeus

♂ albedo-flavus, ♀ niger, macula permagna, curvata, basali, aurantiaco-tincta, ornatus. ♂ antennarum articuli 2 primi antice, maculaque interantennalis albedo-flavescentes; ♀ articulus primus antennalis antice aurantiacus, macula interantennali bicolore. Maculæ postoculares verticis minutæ, flavescentes. Maculæ pronotales sat magnæ, aut bicolores, aut rufescentes. Scutellum bimaculatum; mesopleura aut flavo-aut aurantiaco-maculata. Propodeum utrinque juxta basim suam notatum. Tibiæ omnes ♂ cum metatarsis intermediis et posterioribus fere totæ albidæ; ♀ tibiæ intermediæ et posteriores supra longe albescentibus; femora posteriora utriusque sexus ferruginea; anteriora et intermedia plus minusve albedo-variegata. Tegulæ albedo-cinctæ. Clypeus levissime emarginatus, ♂ opacus, convexus, dense argenteo-pubescent, obsoletim punctatus, inter hæc puncta majora densissime et subtilissime punctulatus; ♀ pernitidus, distincte sparsim punctatus, inter hæc puncta parcissime, vix evidenter, minutissime punctulatus. Frons capitis parum profunde punctata. Anguli pronotales fere recti, haud prominentes. Scutellum distincte, nec dense, punctatum, postscutello inermi; propodei lateribus rotundatis. Abdominis segmentum secundum dorsale haud fortiter convexim elevatum, tomentosus, pilis erectis carens; ventrale, post sulcum transversum, sat fortiter, suboblique supra partem basalem suam elevatum, elevatione summa haud prominente. Segmentum ♂ ventrale 7 pilis brevissimis erectis vestitum. Alæ hyalinæ, costali parte sola infuscata; tegulis glaberrimis, nitidis, ex majore parte impunctatis. Long. 8-9 mm.

*Hab.* Bacchus (or Bocchus?) Marsh; given to me by my late friend, G. W. Kirkaldy.

### 33. PARALASTOR DESPECTUS, sp. n.

♀. Nigra, parte basali clypei macula, antice emarginata, aurantiaca ornata. Frons interantennalis aurantiaco-notata. Antennarum articulus primus antice flavo-lineatus. Maculæ postorbitales verticis minimæ, flavæ. Pronotum rufescens, antice utrinque plus minusve flavescent, nigro-marginatum. Postscutellum utrinque macula parva aurantiaca aut rufescente ornatum. Abdominis segmentum primum, parte nigra declivi excepta, fere totum rufescens et postice albedo-flavo-marginatum; secundum fascia simili decoratum, antice emarginata, latera versus fere ad medium segmentum extensa. Clypeus levissime emarginatus, margine apicali elevato, sat dense, grossius punctatum, et cum oculorum sinu conspicue albo-pubescent. Anguli pronotales haud prominentes. Mesonotum cum scutello nitidum, illo dense et grosse punctato, postscutello inermi. Tegulæ ex majore parte glabræ, politæ, nigre, margine ipso testaceo. Alæ fere hyalinæ, costa magis infuscata. Abdominis segmentum 2 dorsale ad basim fortiter convexum; ventrale post sulcum fortiter

supra partem suam basalem elevatum, elevatione summa haud prominente sive tuberculiformi. Tibiæ ferrugineæ, intermediae et posteriores intra infuscatæ sive nigricantes, his supra flavolineatis, tarsis nigricantibus, articulo apicali pallescente. Antennæ brevès et crassæ. Long. 8 mm.

*Hab.* W. Australia; 1 ♀ in the British Museum.

34. *PARALASTOR TRICOLOR*, sp. n. (Pl. I. fig. 5.)

♀ colore *P. despecto* simillima, sed postscutello haud binotato, scutello bimaculato, mesopleuris notatis, abdominis segmento secundo minus late fasciato, fascia fere recta.

♂ clypeus flavus aut flavus et aurantiacus, medius fusco- aut nigro-maculatus. Antennarum articulus primus rufescens, antice flavescens, secundus nonnunquam rufescens. Macula interantennalis, maculæ pronotales, scutellares et mesopleurales aurantiacæ, aut plus minus flavescentes aut rufescentes. Tegulæ rufescentes aut flavo-variegatæ. Abdominis segmentum primum supra rufum, antice nigro-emarginatum, postice flavo-marginatum. Tibiæ tarsique rufescentes.

♀ ac ♂ fere similiter colorata, sed clypeus ex magna parte est niger, lateribus flavis aut aurantiacis, tibiis supra sape longe flavescens.

♂ clypeus distincte nec profunde emarginatus, parce punctatus, punctatione minutissima, inter puncta majora, distincta. ♀ clypeus plerumque levius, quam maris, emarginatus, et crebrius, distinctissime punctatus. Mesonotum fortiter denseque punctatum, postscutello inermi, propodeo rotundato, distincte punctato, angulis pronotalibus parum distinctis. Abdominis segmentum secundum dorsale pilis erectis, haud densis (et facile detritis), ubique vestitum, basim versus (præcipue ♂) sat convexum. Segmentum 2 ventrale fortissime post sulcum transversum elevatum, elevatione summa prominula. Segmentorum sequentium apices sæpe aurantiacæ, aut plus minus pallidæ. Alarum pars costalis distincte infuscata, partibus cæteris leviter infuscatis. ♂ antennæ 11 articulatæ, articulis 3 ultimis minutis, ♀ haud plus quam solito incrassatæ. Long. 8-9 mm.

This species somewhat resembles the preceding *P. despectus*, but is probably not very closely allied, as the female—this being the only sex known of the other—has the clypeus much less short and much less convex, and the punctures are much less close. The second ventral abdominal segment is more strongly raised, the top of the truncation in the middle being of more pointed form, the second dorsal segment less abruptly and strongly raised from the base etc., and the coloration of the insect is brighter. It is excessively like *P. picteti* Sauss. in the other section of the genus. The emargination of the clypeus is very shallow in some females, rather deeper in others.

*Hab.* Queensland, Cairns, 2 ♀, 1 ♂. July; Kuranda (*Dodd*), 1 ♀; Mackay and Kuranda, several examples (*Turner*).

35. *PARALASTOR ROSEOTINCTUS*, sp. n.

♀. Nigra; abdominis segmentum primum supra (sc. parte declivi excepta) fere totum pallide aurantiacum, antice nigro-emarginatum; segmentum secundum fascia lata apicali, lateraliter fere ad medium attingente, ornatum. Clypeus maculis duabus curvatis magnis lateralibus, nonnunquam ad basim una conjunctis, notatus; macula interantennalis magna, postorbitalis parva. Antennarum articulus primus antice, aut totus, aut basim versus, aurantiacus aut rufescens. Maculae pronoti magnae, ad medium ejus longitudinem attingentes, nonnunquam una conjunctae (sc. haud interruptae), et fasciam formantes. Mesopleura notata; tegulae mesonotum juxta nigricantes. Scutellum, postscutellum et propodeum aut utrinque notata, aut tota nigra. Alae hyalinae, parte costali parum late infuscata. Tibiae tarsique rufescentes. Color picturationis est insolitus, pallide roseo-tinctus. Clypeus subnitidus, fortiter punctatus, puncturatione minutissima interstitiali sat distincta, apice leviter emarginato. Frons capitis densissime (nec profunde) rugose punctata. Anguli pronotales distincti, nec acuti. Mesonotum sat grosse rugoso-punctatum, tegulis in parte exteriori haud evidenter punctulatis, postscutello inermi. Abdominis segmentum primum haud evidenter transversim impressum, rugoso-punctatum; secundum dorsale fortissime in formam conicam elevatum; ventrale, post sulcum suum, distincte (nec fortissime) supra partem suam basalem elevatum, elevatione summa late rotundata, haudquaquam subacute prominula. Long. 8.5 mm.

The variation in the colour of the hind parts of the thorax is unusual, but I have no doubt the two examples are of the same species. The clothing of the thorax is not at all dense, so that the sculpture is very easily seen. The very strong and pointed elevation of the second dorsal segment of the abdomen is like that of *P. tuberculatus* Sauss. alone of all the species known to me.

*Hab.* Australia, Swan River, 1 ♀; W. Australia, 1 ♀.

36. *PARALASTOR XEROPHILUS*, sp. n.

♂. Niger; clypeus, macula interantennalis, lineaque orbitalis, in oculorum sinus extensa, flavescentia. Antennarum articulus primus antice aurantiacus, et plus minus flavescent. Maculae postoculares verticis minores, elongatae, aurantiacae. Pronotum, desuper aspectum, fere totum late aurantiacum, propodeo utrinque macula parva (an semper?) rufescente ornato. Femora, tibiae tarsique aurantiaca. Abdominis segmentum primum dorsaliter totum aurantiacum, hoc colore in partem declivem extenso, basi nigra; segmentum secundum late aurantiaco-fasciatum, fascia fere recta, aut tantum antice paullo concavo; segmenta 2 sequentia aurantiaco-fasciata. Clypeus distincte, nec profunde, emarginatus, haud dense, grossius sed leviter, punctatus, et inter puncta majora dense minutissime punctulatus, argenteo-pubescent. Frons capitis, cum mesonoto et propodeo,

quam densissime rugoso-punctata, postscutello inermi. Anguli pronotales distincti, truncationis margine distincte elevato. Tegulae in parte exteriori, qua sunt latissimae, impunctatae vel fere impunctatae, puncturatione minuta absenti. Alae subinfusatae, parte costali saturatiore, basim versus flavescente. Abdominis segmentum primum rugoso-punctatum, medium impressum; secundum dorsale basim versus subfortiter convexum; ventrale, post sulcum costatum, fortiter elevatum, elevatione summa paullo prominula, ibique grosse rugoso-punctatum; segmenta apicalia tomentosa, ultimo pilis paucis brevioribus suberectis vestito, minutissime dense punctulato, haud impresso. Long. circa 11 mm.

*Hab.* Central Australia, Hermansburg (*H. J. Hillier*), 1 ♂.

### 37. *PARALASTOR PLACENS*, sp. n.

♀. Nigra, clypeo, macula interantennali, et duabus verticis postocularibus, pronoto, maculis subtegularibus, duabus magnis scutellaribus et propodealibus, duabus postscutellaribus, abdominis segmentum primum, triangulo elongato nigro basali, cujus apex superficiem superiorem intrat, excepto, margine postico secundi sat late, femoribus, tibiis tarsisque aurantiacis aut rufo-aurantiacis. Fascia segmenti secundi media antice excisa, segmentis sequentibus nigris. Tegulae ex majore parte aurantiacae. Alae subhyalinae, costali parte infusata. Clypeus nitidus, subtiliter perparce punctatus, punctis minutissimis etiam parvis, apice distincte, nec profunde, emarginato. Frons capitis grosse punctata, punctis sat distinctis. Pronoti truncatio haud marginata. Mesonotum dense subrugosim distincte punctatum, punctis scutellaribus remotioribus. Postscutellum distincte punctatum, inerme. Tegulae politae, puncturatione minutissima in parte exteriori carentes. Abdominis segmentum primum subirregulariter punctatum, medium impressum; secundum dorsale sat elongatum, lateribus perpaullo rotundatis, fascia apicali excepta, tomento nigerrima; ventrale, post sulcum, fortissime abrupte elevatum, post elevationem haud grosse punctatum. Long. circa 9 mm.

*Hab.* Australia, Swan River, 1 ♀.

### 38. *PARALASTOR ERIURGUS* Sauss.

The only examples of this large and robust species that I have seen with a definite locality-label are from Queensland. The apex of the clypeus is very distinctly margined, at least in the female.

The male has the usual 11-jointed antennae, with the three apical joints minute. The third and following ventral segments of the abdomen are quite densely hairy, the apical segment bearing quite long erect hairs, being finely punctured and without an impression. The clypeus is densely pubescent, the larger punctures obsolescent, the minute puncturation dense. The

tegulae in both sexes have a close minute puncturation on their outer portion. The amount of black on the clypeus of the female varies and probably may be altogether absent, while in some the orange colour is reduced to a wide curved or horseshoe-shaped mark. The single male has only a small black spot near the apex.

*Hab.* Queensland, Brisbane (*Hacker*), 4 ♀ taken singly in Jan., Feb., March, and April. Four other ♀ and 1 ♂ examined.

### 39. PARALASTOR ARGENTIFRONS Smith.

This species structurally seems to be almost identical with *P. eriurgus* and is perhaps only a southern race of the Queensland form, but is very different in superficial appearance. It varies greatly in the width of the abdominal fasciae of the first two segments. Of the 13 examples before me I do not think that there are even two that are alike in the pattern of coloration of the second dorsal segment. One example, in which the black forms an equilateral basal triangle, bears a MS. label, "*saucius* Sauss. Type." The clypeus in the single male bears a black median apical spot, in the female it may be all black or marked at the base; it also varies in puncturation, and in some examples is quite dull, in others more shining. The pronotal spots may be absent. In some examples the upper edge of the truncation of the second ventral segment is less pointed in the middle (as in the type) than in others, but I have examples taken in company which differ in this respect, but not otherwise. The silvery pubescence of the sides of the clypeus and adjoining orbits is more distinct and conspicuous in some than in others. The male characters are as in *P. eriurgus*.

*Hab.* Adelaide (my collection), 3 ♀, 1 ♀ & 1 ♂ (Oxford Museum); S. Australia, 1 ♀ (Oxford Mus.) and 1 ♀ (British Museum); Victoria (*French*), 4 ♀; 2 ♀ without special locality.

### 40. PARALASTOR SUBOBSCURUS, sp. n.

♂. Niger, clypeo flavo, medio nigro-punctato, macula elongata interantennali maculaque parva verticis postoculari, flavis. Maculae pronotales, mesopleurales, et scutellares aurantiacae. Tegulae aurantiaco-marginatae. Abdominis segmenta 2 basalia postice rufo-marginata (vix aurantiaca) fasciis fere rectis, minus latis. Tibiae tarsique ferruginei aut rufescentes. Alae infuscae, parte costali saturatiore.

Species villosa, *P. eriurgo* et *argentifrons* angustior. Clypeus fortiter emarginatus, nitidus, remote punctatus, minus pubescens. Frons rugoso-punctata. Pronoti truncatio haud evidenter marginata, angulis tamen lateralibus distinctis. Mesonotum grosse punctatum, punctis distinctis, minus confluentibus. Postscutellum inerme. Propodeum distincte punctatum. Abdominis segmentum primum subaequaliter punctatum, pilis longis vestitum; secundum

dorsale pilis brevibus erectis sparsim vestitum, dense nigro-tomentosum; ventrale fortissime post sulcum transversum elevatum, elevatione summa acutius prominula, puncturatione vix grossa aut densa; segmentum ultimum, cum præcedentibus, pilis sat longis erectis vestitum. Tegulæ in parte exteriori minutissime punctulatæ, punctis subobsoletis. Long. 9.5 mm.

*Hab.* North Queensland (*Dodd*), 1 ♂.

#### 41. *PARALASTOR SIMPLEX*, sp. n.

♀. Nigra, macula interantennali, aliisque duabus minutis postocularibus aurantiacis. Pronotum et mesopleura maculis magnis aurantiacis ornata. Scutellum juxta marginem suum posteriorem et postscutellum fascia interrupta aurantiaca ornata. Tegulæ pallidæ; alæ subflavo-infuscatæ. Tibiæ tarsique ferruginei, illis aut externe aut subtus nigricantibus, articulis tarsorum nonnullis etiam plus minusve infuscatis. Abdominis segmenta 2 basalia aurantiaco-fasciata, fasciis haud latis, fere æqualibus. Clypeus levissime emarginatus, parce subtilius punctatus, inter puncta majora parce subtilissime punctulatus, opacus. Pronoti truncatio (parte media excepta) fortiter elevato-marginata. Mesonotum fortiter densissime punctatum, postscutello inermi. Abdominis segmentum primum quam densissime punctatum; secundum dorsale dense nigro-tomentosum, basi haud convexim elevata; ventrale, post sulcum transversum, fortissime elevatum, elevatione summa conspicue prominente. Tegulæ opacæ, punctis paucis majoribus exceptis, impunctatæ. Long. 13 mm.

This appears to be a very distinct species, but the single example is much abraded, and the flavescent appearance of the wings may be partially due to age, but on the other hand these may be still yellower in fresh examples, as the stigma itself is more or less pale in colour.

*Hab.* Albany (*Brewer*), 1 ♀.

#### 42. *PARALASTOR MIMUS*, sp. n.

♀. Angusta, nigra; macula interantennalis, cum duabus elongatis postocularibus, pronotum, tegulæ, scutellum, postscutellum, propodeum, maculæ mesopleurales, abdominis segmentum primum (parte decliva majore excepta), femora, tibiæ tarsique, nonnunquam etiam coxæ et trochanteres, rufa aut flavo-rufa. Clypeus aut totus niger, aut totus rufescens, aut niger, rufo-tinctus. Alæ, costali parte excepta, parum infuscatæ. Clypeus distincte emarginatus, punctis majoribus et minutissimis commixtis signatus, pubescens. Mesonotum posticè irregulariter punctatum; postscutellum inerme. Tegulæ minutissime punctatæ, puncta complura majora nonnunquam ferentes. Abdominis segmentum primum breviter campanulatum, vix densissime punctatum; secundum ad basim conspicue angustatum, lateribus fere rectis aut parum rotundatis, satis longum, basim versus fortiter convexum. Segmentum 2 ventrale post sulcum transversum

fortissime elevatum, elevatione summa haudquaquam acute prominente, fortiter punctatum. Long. circiter 9 mm.

Very distinct from any of the preceding species by its colour, narrow elongate form, the longer first abdominal segment, long subparallel-sided second segment, etc. It might almost be placed in the other division of the species here described, and is included in the tables of both divisions.

*Hab.* Australia, Swan River, 3 ♀ (two in the Oxford and one in the British Museum); 1 ♀ in very bad condition is labelled "New South Wales," probably in error.

#### 43. PARALASTOR IMITATOR, sp. n. (Pl. I. fig. 10.)

♀. Præcedenti simillima, sed minor, tegulis grosse punctatis, puncturatione minutissima absente, antennis brevibus et crassis facile distinguenda.

Form, colour, and general appearance almost exactly as in *P. mimus*. In the single specimen the clypeus is black on about the apical third, its apex is very lightly emarginate. The fourth, fifth, and sixth antennal joints are extremely strongly transverse. The tegulæ are very shining, conspicuously, coarsely, and deeply punctured, and without the numerous minute punctures that form the chief sculpture in *P. mimus*. The wings are still clearer, with very little infuscation along the costa. The basal abdominal segment is rather shorter and the second less abruptly narrowed at the base. The second ventral segment is considerably less strongly raised behind the transverse sulcus. Long. 7.5 mm.

This species is very distinct.

*Hab.* Australia, Champion Bay, 1 ♀.

#### 44. PARALASTOR DEBILIS, sp. n. (Pl. I. fig. 20.)

♂. Niger, clypeo, antennarum articulo primo antice, maculaque postoculari minuta, flavescentibus. Pronoti fascia, utrinque dilatata, pars tegularum exterior, notæ parvæ scutelli duæ, fascia sat lata postscutellaris, abdominis segmentum primum, parte declivi excepta, fascia secundi apicalis, aurantiaca aut aurantiacorum. Tibiæ ferrugineæ, tarsis ex majore parte fusco-brunneis. Clypeus brevis, sat convexus, apice levissime emarginato, dense argenteo-pubescentibus. Frons capitis pilis crebre vestita. Pronoti truncatio fere recta, aut perpaullo concava, distincte elevato-marginata. Mesonotum densissime fortiter punctatum, scutello similiter punctato, postscutello inermi. Tegulæ nitidæ, grosse et conspicue punctatæ. Abdominis segmentum primum, quam densissime, grosse punctatum, secundum etiam densissime ubique punctatum, basi fortiter convexim elevata. Segmentum 2 ventrale post sulcum transversum distincte (sed haud fortissime) supra partem basalem suam elevatum, elevatione summa haudquaquam acutius producta, post hanc late et conspicue impressum, et crebre punctatum; segmenta apicalia appresse

pubescentia, ultimo pilis paucis longioribus erectis vestito. Long. circa 7 mm.

The pronotal band at its widest hardly reaches the middle of the length of the pronotum; the second abdominal segment is thinly clothed with more or less erect hairs, its apical fascia is not dilated at the sides, and only moderately wide, not occupying more than about one-fifth of the segment.

*Hab.* West Australia, Swan River, 1869, 1 ♂ (*de Boulay*), in the Oxford Museum.

#### 45. *PARALASTOR EUGONIAS*, sp. n.

♂. Niger; clypeus maculaque interantennalis elongata aurantiaco-flavescentes. Pronoti maculae duae, et tegulae ex maiore parte, rufescentes. Segmentum abdominis primum et secundum postice rufo-marginata, fascia prima latera versus angustata, secunda utrinque valde dilatata, ibique ante aut ad medium segmenti longitudinem extensa, caeteris segmentis (saltem ex maiore parte) rufis aut aurantiacis. Tibiae tarsique rufescentes. Species minor, sed haud gracilis. Clypeus lunulato-emarginatus, ex maiore parte subdeplanatus, distincte, remote, haud grosse punctatus, basi lateribusque suis argenteo-pubescens. Frons cum thorace crebre pilosa. Mesonotum dense punctatum, scutello inermi. Tegulae grosse et conspicue punctatae. Abdominis segmentum secundum dorsale dense, grossius punctatum, parte basali fortiter convexa; ventrale, post sulcum, fortiter abrupte elevatum, et postice grosse denseque punctatum. Anguli posteriores segmenti 2 dorsalis conspicue acute producti. Long. circiter 8 mm.

*Hab.* Adelaide (*A. K. Davis*), 1 ♂.

#### 46. *PARALASTOR MICROGONIAS*, sp. n.

♂. Praecedenti simillimus, clypeo brevior et angulis segmenti 2 dorsalis abdominis posterioribus perpaullo productis distinguendus. Long. circiter 7 mm.

Exactly like the preceding in general appearance, but the clypeus is distinctly less produced apically and less flattened, and its puncturation rather coarser. The lateral angles of the hind margin are only very slightly produced backwards. The wings are hardly infuscate, except along the costa, where the infuscation is dark and conspicuous. In the preceding species the wings are folded and appear dark, but this may be only due to the folding. Both species have a small postocular spot on each side of the head, which was not mentioned in my description of the preceding.

In both, the apical antennal joints are excessively minute, forming a sort of small tubercle in the concavity of the eighth, and it is difficult to tell whether two or three joints are here present, but I have satisfied myself that there are three, so that the antennae are normal for the genus, 11-jointed.

*Hab.* Adelaide, 1 ♂ (British Museum).

47. *PARALASTOR SANGUINEUS* Sauss.

I examined the type of this species in the British Museum, but unfortunately have not been able to make an actual comparison between it and the two preceding, one or other of which may be only a variety of *sanguineus*. It has the apex of the clypeus much more widely black, in the preceding only the actual margin being black. From a rough sketch that I made, it is also, possibly, more produced. The red apical band of the second dorsal segment of the abdomen is produced further towards the base on each side. These colour-characters, however, would of themselves be insufficient for specific distinction. I did not observe the hind angles of the second dorsal segment.

It certainly appears probable that one or other of these males belongs to the female described as *vulneratus* Sauss., but the very different clypeus forbids us to associate them without further evidence. It is usual for the male clypeus to be more deeply emarginate than that of the female, whereas in the males and females in question, the clypeus of the female is extraordinarily deeply emarginate, far more strongly than in the male. Nevertheless, I suspect that *sanguineus* Sauss. and *vulneratus* Sauss. are sexes of one species.

*Hab.* Australia (British Museum).

48. *PARALASTOR ARGYRIAS*, sp. n.

♂ colore *P. sanguineo* Sauss., congruens, sed clypeo toto flavo, antennarum articulo primo antice flavescente, maculisque pronotalibus magnis, fasciam vix interruptam, utrinque dilatatam, formantibus. Alæ hyalinæ, costali parte infusca. Clypeus fere æqualiter conspicue convexus, parum profunde et fere æqualiter punctatus, puncturatione interstitiali crebra, ubique argenteo-pubescent. Oculorum sinus utrinque flavo-notatus. Anguli pronotales parum distincti. Mesonotum dense punctatum, scutello inermi, propodeo brevi et rotundato, tegulis grossissime punctatis. Abdominis segmentum primum dense, distincte punctatum, lateribus suis, cum lateribus basalis partis secundi, conspicue argenteo-tomentosis. Segmentum secundum dorsale latera versus copiose, sed haud densissime, punctatum, basali parte fortiter supra segmentum primum convexim elevata, fascia apicali utrinque fere ad medium segmentum attingente, antice emarginata; segmentum 2 ventrale, post sulcum transversum, fortiter abrupte elevatum, post elevationem summam depressum, puncturatione distincta, haud densa; segmentum septimum pubescentia decumbente vestitum, pilis longis erectis carens. Long. circiter 9 mm.

A very distinct species structurally, but resembling *P. eugonias* in colour and pattern, except for the yellow front of the scape and the much greater development of the pronotal markings.

*Hab.* New South Wales, Wagga (*Froggatt*), 1 ♂.

49. *PARALASTOR EUCLIDIAS*, sp. n.

♂ picturatione fere *P. argyriæ* ornatus, sed fascia segmenti 2 abdominalis fere ad basim utrinque protracta. Clypeus, antennarum articulus primus antice, macula elongata interantennalis, duæ postoculares, flavescentia aut flavo-aurantiaca. Maculæ duæ pronotales aurantiacæ. Tegulæ incomplete rufo-marginatæ. Abdominis segmentum primum postice late aurantiaco-fasciatum, fascia antice emarginata; fascia secundi fere ad basim segmenti utrinque producta (sc. segmentum secundum aurantiacum, et triangulo magno nigro basali ornatum). Tibiæ, tarsi apicesque femorum aurantiaco-fulvescentes. Segmentum abdominalis tertium dorsale, cum sequentibus, aurantiacum, segmentis ventralibus (quæ post secundum posita sunt) atris, apicibus pallidioribus. Clypeus sat longus, distincte emarginatus, obscure sparsissime punctatus, et ubique densissime et minutissime punctulatus, ubique argenteo-pubescent. Frons capitis dense, nec profunde punctata. Mesonotum crebre punctatum, scutello sat convexo, postscutello inermi, tegulis grosse punctatis, propodeo utrinque rotundato. Abdominis segmentum primum rugose punctatum; secundum (in aspectu laterali) basim versus fere æqualiter curvatum, sive convexum, latera versus punctis inter se ex magna parte distinctis, haud ubique rugosim confluentibus. Abdominis segmentum 2 ventrale post sulcum suum transversum, fortissime elevatum, elevatione summa conspicue prominente, post elevationem depressum et subfortiter sed vix grosse punctatum; segmentum ultimum latum, brevissime pubescens. Alæ, costali parte excepta, levissime infuscatæ. Antennæ 11-articulatæ. Long. circiter 10 mm.

As in many species, there is a silvery pubescence, conspicuous in some aspects, along the lower part of the inner orbits and filling the sinus of the eyes.

*Hab.* Victoria, Gippsland (*Froggatt*).

50. *PARALASTOR OCCIDENTALIS*, sp. n.

♂. Niger, clypeo, macula elongata interantennali, articulo primo antennarum antice, duabusque notis postocularibus, aurantiacis. Pronotum, angulis deflexis inferioribus exceptis, totum, scutellum postscutellumque, macula magna mesopleuralis, coxæ (basi excepta), femora, tibiæ tarsisque, cum lateribus propodei, duabusque maculis mesonotalibus triangularibus, rufescentibus, vix aurantiacis. Tegulæ partibus thoracis cæteris pallidius coloratæ. Abdominis segmentum primum (parte declivi excepta), fasciæque, minus lata, apicalis segmenti secundi, rufa. Clypeus sat longus, apice distincte, leviter emarginatus, densissime minutissime punctulatus, punctis majoribus paucis interspersis, argenteo-tomentosus. Frons capitis rugose punctata. Pronotum fere recte truncatum, truncatione bene elevato-marginata. Pronotum, mesonotum et scutellum densissime punctata, scutello haud evidenter armato. Tegulæ profunde et grosse punctatæ. Abdominis

segmentum primum densissime rugoso-punctatum, secundum basim versus haud fortiter convexim elevatum, a latere visum, tantum mediocriter convexum. Segmentum 2 ventrale, post-sulcum, fortissime abrupte elevatum, elevatione summa conspicue prominente, sive tuberculata; segmentum ultimum latum, subdepressum, brevissime pubescens. Alarum pars costalis usque ad stigma pallidum conspicue flavescens, parte cætera plus minusve violaceo-nitente. Antennæ 11-articulatæ. Long. 12 mm.

*Hab.* Australia, Swan River; 1 ♂ in the British Museum.

#### 51. PARALASTOR ORIENTALIS, sp. n. (Pl. I. fig. 21.)

Niger, clypeo, macula interantennali, duabusque postocularibus, antennarum ♂ articulo primo antice, pronoto supra usque ad tegulas, scutelli et postscutelli aut fascia completa aut maculis duabus, propodeo utrinque, abdominis segmento primo (parte declivi excepta) fere toto, apicali fascia secundi cum sequentibus, tibiis tarsisque et sæpe parte femorum majori, aurantiacis. Clypeus et macula interantennalis sæpe, quam maculæ cæteræ, flavescentiores. Alæ distincte ubique infuscatæ, costali parte saturatiore. Clypeus distincte, nec profunde emarginatus, ♀ fortiter, ♂ multo obscurius, punctatus, puncturatione minutissima densa et conspicua. Mesonotum dense rugoso-punctatum, scutello inermi, tegulis fortiter punctatis. Abdominis segmentum primum distincte punctatum, pilis erectis perparce vestitum; segmentum secundum tomento pernigrum, pilis erectis carens, fascia apicali latera versus paullo latiore. Segmentum 2 ventrale, post sulcum, fortissime elevatum, elevatione summa prominula, anterius producta, segmento ultimo ♂ subdepressum, pubescens, pilis erectis parum vestito. Long. 9–11 mm.

The orange colour varies in depth, being redder in some and yellower in others. Sometimes there are two orange spots on the mesonotum in front. There is also variation in the amount of puncturation of the tegulæ. I have seen only six examples, and four of these are without special locality.

*Hab.* New South Wales, 1 ♀ (British Museum); 1 ♀, Queensland, Bundaberg, taken by myself; 2 ♂ 2 ♀, Oxford Museum, and 1 ♀, British Museum, without special locality.

#### 52. PARALASTOR LACHESIS Sauss.

This species has the same coloration as *P. orientalis*, and may be identical with it. Owing to the fact that the sculpture of the tegulæ is not referred to in Saussure's description, I cannot place it in my tables. The clypeus is said to be "strongly emarginate," whereas the term is not as a rule used by Saussure for species which have the clypeus no more strongly emarginate than *P. orientalis*.

*Hab.* Tasmania, according to Saussure, but I have seen no Tasmanian species with this style of coloration, which is so

common on the mainland. Two other species, *P. picteti* and *P. tasmaniensis*, recorded from Tasmania, are known to me only from Queensland, and the possibility of error in Saussure's localities seems to be considerable.

### 53. PARALASTOR NAUTARUM Sauss.

This species, described on a single male, should probably be placed near *P. orientalis*, as I have a note that the tegulæ are very coarsely punctured, the clypeus distinctly, but not deeply, emarginate. Superficially at least it is quite distinct from this or allied forms, by the first segment of the abdomen being orange with a black spot on its declivous basal portion, the second and following ones being entirely black. The ventral surface of the abdomen has a short dense pubescence.

*Hab.* Australia (British Museum).

### 54. PARALASTOR SOLITARIUS, sp. n. (Pl. I. fig. 6.)

♂. *P. orientali* colore et vestitu simillimus, sed minor, orbitis interioribus aurantiaco-fasciatis, maculis postocularibus magnis, elongatis, ante medium oculorum marginem anteriorem extensis, fascia pronotali haud ad tegulas extensa, tegulis ipsis inter puncta majora minutissime punctulatis, abdominis segmento 2 ventrali, post sulcum, multo minus fortiter elevato, elevatione summa haud aut vix antice producta, facillime distinguendus. Long. circiter 7 mm.

I have seen only one example of this species, which in general appearance and sculpture resembles *P. orientalis*. The orange of the basal segment is emarginate with black in the middle in front, as in the other, but the second segment is less conspicuously deep black, owing to the less dense tomentum, and the puncturation therefore appears much more distinct. The tegulæ bear less numerous punctures than is usual in this group.

*Hab.* Queensland, Bundaberg, 1 ♂, taken by myself.

### 55. PARALASTOR HILARIS, sp. n. (Pl. I. fig. 18.)

♂. Caput flavum, colore flavo postoculari ab colore flavo frontali separato, vertice nigro, hoc colore late in frontem producto. Antennarum articulus primus, cum maxima mandibularum parte, flavus. Pronotum, scutellum, postscutellum, propodeum utrinque, mesopleura antice, et tegulæ, flava, plus minusve hic illic aurantiaco-tincta. Coxæ, trochanteres, femora, tibiæ tarsique flava, nonnullis in partibus brunnescentia. Abdominis segmentum primum, parte declivi excepta, flavum, antice nigro- aut brunneo-nigro emarginatum; segmentum secundum ad basim brunneum, medium nigrum, postice sat late flavo-marginatum, segmentis sequentibus plus minusve flavis. Antennarum flagellum subtus plus minusve rufescens. Clypeus sat longus, apice distincte emarginato, subæqualiter nec dense punctatus, puncturatione

minutissima inter puncta majora densa. Frons capitis cum thorace brevissime pilosus. Mesonotum nitidum, densissime, fortiter punctatum, scutello inermi, tegulis grosse et profunde punctatis. Abdominis segmentum primum latissimum, fortiter punctatum, pubescentia minutissima decumbente excepta, fere nudum; segmentum secundum fortiter convexim elevatum, pilis erectis carens, distincte crebreque punctatum. Segmentum 2 ventrale post sulcum sat abrupte, sed minus fortiter, supra partem suam basalem elevatum, elevatione summa quasi incrassationem transversam formante, post hanc depressum et subtilius nec dense punctatum; segmentum ultimum pilis erectis evidenter vestitum, leviter convexum, et subtiliter, nec dense, punctatum. Alæ fere hyalinæ, costali parte conspicue infuscata. Long. circiter 7 mm.

*Hab.* Northern Australia, Port Darwin; North Queensland? (*Dodd*).

#### 56. PARALASTOR MACULIVENTRIS SAUSS.

I think it probable that this species may be identical with my *P. elegans*, described above. Saussure says nothing of the strongly raised elongate clypeal carinæ, which Mr. Meade-Waldo informs me occur in Saussure's type, as in *P. elegans*. He also informs me that the type specimen is deformed, the sides of the face being asymmetrical. The only difference, so far as I can judge, between the two forms is that in *P. maculiventris* the apical band of the first abdominal segment is entire, not disappearing before it attains the lateral angles, that the head is said to be covered with a blackish tomentum (pale in *P. elegans*, and conspicuously golden in front), the "inner borders of the eyes are yellow" (only a yellow spot in the *sinus* in *P. elegans*), while the latter has the postscutellum hardly perceptibly tuberculate.

*Hab.* Australia. Type in the British Museum.

#### 57. PARALASTOR BICARINATUS, sp. n.

Niger, macula interantennali, duabus postocularibus, duabus pronotalibus, maculis duabus, aut una magna, scutellaribus, duabus propodealibus, tegulis, segmentum primum abdominis (parte declivi excepta) ex majore parte, secundique fascia apicali, plus minusve antice utrinque producta, cum parte apicali segmentorum sequentium, flavis. ♂ clypeus totus, antennarumque articulus primus antice, flavi; ♀ clypeus medius, cum lateribus extra carinas niger. Alæ fere hyalinæ, costali parte infuscata, stigmatibus atro-fusco. Tibiæ tarsique apicesque femorum flavescens. Color flavus plus minus aurantia-tinctus. Clypeus fortiter emarginatus et acute dentatus, parce punctatus, inter puncta majora minutissime punctulatus, fortiter productus, et duabus carinis elongatis, acute elevatis, munitus. Frons capitis grosse et distincte punctata, interstitiis inter puncta minute punctulatis. Mesonotum grosse punctatum, pilis erectis longioribus vestitum, pronoto antice parum distincte marginato,

scutello inermi. Tegulae parum nitidae, minutissime obsoletim punctulatae, punctis nonnunquam tribus aut duobus majoribus notandis. Abdominis segmentum primum minus fortiter punctatum; secundum ad basin subfortiter convexum. Segmentum 2 ventrale post sulcum fortissime elevatum, elevatione summa sat fortiter prominente; segmentum ultimum ♂ subconvexum, haudquaquam depressum, breviter pilosum. Long. 9-11 mm.

In the male the yellow of the first segment is nearly straight in front, in the female it is emarginate in the middle. The apical band of the second segment in the male does not reach the middle of the segment, in the female it extends far beyond the middle basally. I think this is mere individual variation and probably not a constant sexual difference.

*Hab.* Queensland, Mackay (*Turner*); 1 ♂ and 1 ♀.

#### 58. PARALASTOR ATRIPENNIS, sp. n. (Pl. I. fig. 13.)

♀ color colori varietatum *P. argentifrontis* nonnullarum perfecte similis, sed alis atris ubique violaceo-nitentibus primo aspectu distinguenda. Maculae parvae interantennales cum duabus postocularibus aurantiacae. Segmentum primum abdominis fascia apicali fere recta, haud dimidiam partem suam in aspectu dorsali occupante, secundum fascia lata rufescente, antice emarginata, latera versus ante medium segmentum protracta, ornatum, cæteris segmentis his fasciis colore fere similibus. Tibiae tarsique rufescentes. Tegulae obscurius rufescentes. Clypeus fortiter emarginatus, dentibus lateralibus obtusis, inter hos margine nonnullis in aspectibus perpaullo prominente, ut quasi obscure tridentatus appareat, nitidus, antice fortius, postice subtilius punctatus, et inter puncta majora minutissime punctulatus. Frons capitis rugosa, punctis obscurissimis. Mesonotum subopacum, puncturatione inaequali, punctis nonnullis grossioribus, nonnullis minus grossis commixtis. Postscutellum medium paullo productum, sive obscure tuberculatum. Tegulae dense minutissime punctatae, punctis perpaucis majoribus praesentibus. Abdominis segmentum secundum ventrale post sulcum transversum fortissime abrupte elevatum, elevatione summa prominula. Long. circa 14 mm.

I have seen only one old example in dirty condition. It is very distinct from any other that has similar coloration and markings. The clypeus is more or less flat over most of its surface, excepting the base and the decurved sides.

*Hab.* Adelaide (*Wilson*); 1 ♀ in the Oxford Museum.

#### 59. PARALASTOR AUREOCINCTUS Guér.

There is a single female of this species in the British Museum, bearing a label "*Alastor eriurgus*, var." Practically it resembles *eriurgus* in colour, but in structure it is extremely close to the preceding, to which it has no superficial likeness. The tegulae

have the same dense, distinct, minute puncturation and the clypeus is nearly of the same form, as also is the general sculpture. The postscutellum has even less evidence of a tubercle than that of the preceding species. Length about 15 mm.

*Hab.* Australia, without definite locality; 1 ♀ in the British Museum. Judging from the coloration, one would expect to find this species in Queensland.

#### 60. PARALASTOR DENTIGER, sp. n. (Pl. I. fig. 11.)

♂ colore et picturatione fere *P. mimi* (q. v.) ornatus. Notæ postoculares minores, clypeo aurantiaco, margine apicali et nonnunquam linea mediana nigris. Alæ ubique infuscatæ. Clypeus fortiter emarginatus, nitidus, parte media nitida, glabra, depplanata, basi lateribusque decurvatis et dense argenteo-pubescentibus. Frons dense et rugose punctata. Mesonotum densissime punctatum, postscutello tuberculo spinoso conspicue armato, tegulis puncturatione densissima et minutissima carentibus, sed punctis nonnullis majoribus plerumque distinctis. Abdominis segmentum primum transversim subdepressum, plus minusve rugoso-punctatum, colore rufo antice profunde, sed anguste, nigro-emarginato; segmentum secundum dorsale basim versus leviter convexum; ventrale, post sulcum suum transversum, fortissime elevatum, elevatione summa prominente; segmentum ultimum cum præcedentibus pilis erectis evidenter vestitum. Antennæ 11-articulatæ, tribus apicalibus articulis minutis. Long. 11·5 mm.

This is a more robust species than *P. minus* and *imitator*, which it so much resembles superficially. The posterior face of the propodeum is more extensively black than in the former. Structurally it is entirely distinct from both.

*Hab.* Champion Bay and Swan River; 2 ♂ in the British Museum.

#### 61. PARALASTOR INFIMUS, sp. n.

♂ picturatione, forma, et colore *P. eriurgo* simillimus, sed apice clypei haud distinctissime elevato-marginato, et scutello sat conspicue tuberculato bene distinguendus. Clypeus leviter emarginatus, grosse punctatus, nitidus, basi lateribusque dense argenteo-pubescentibus. Frons dense rugoso-punctata. Tegulæ densissime et minutissime punctulatæ. Thorax sat grosse punctatus, pilis erectis ubique conspicue vestitus. Abdominis segmentum primum medium impressum, margine apicali excepto, crebre punctatum. Abdominis segmentum 2 ventrale, post sulcum fortissime elevatum, subopacum, crebre punctatum, elevatione summa prominula, hoc segmento cum sequentibus pilis erectis fere æquilongis vestito, segmento ultimo spatium medianum nitidius, lineis elevatulis definitum, præbente. Long. 12·5 mm.

*Hab.* Queensland, Brisbane (*Hacker*), 1 ♂ in December.

62. *PARALASTOR SUMMUS*, sp. n.

♀. Nigra, clypei lateribus deflexis (parte apicali excepta), macula interantennali, duabus postocularibus, pronotalibus, mesopleuralibus et scutellaribus cum parte tegularum, flavescentibus, aut plus minus aurantiaco-flavis. Abdominis segmentum primum et secundum late aurantiaco-marginata, fascia secunda utrinque ante medium segmentum protracta, segmentis sequentibus, plus minusve aurantiacis. Tibiæ tarsique rufescentes. Clypeus (lateribus deflexis exceptis) deplanatus, nitidus, fortiter in parte apicali punctatus, apice subfortiter emarginato et producto. Frons cum thorace fusco-pilosa. Mesonotum grosse punctatum, inter puncta minutissime punctulatum, sive quasi granulatum, postscutello tuberculato, tegulis densissime punctulatis, opacis. Alæ subhyalinæ, parte costali infuscata. Abdominis segmentum primum ex majore parte subtilius nec dense punctatum, secundum basim versus minus fortiter convexum, tomento pernigro vestitum, pilis erectis parcissimis. Segmentum 2 ventrale post sulcum suum fortissime elevatum, elevatione summa, desuper visa, subangulata. Long. circiter 12 mm.

This is a less robust species than the preceding, and the thorax is notably longer. The flat portion of the clypeus becomes very narrow posteriorly, being closely adapted to, and continuing the plane of, the interantennal plate, when viewed from the side.

*Hab.* Queensland, Cairns, 1 ♀.

63. *PARALASTOR MEDIUS*, sp. n.

♀ præcedenti cognatissima, clypeo brevior, basim versus fortiter sed sparsim punctato, propodeo utrinque maculato, distinguenda.

Very similar to the preceding, but the coloration is still yellower (less orange), the clypeus is reddish apically and the yellow colour of the sides extends to the apical teeth. The yellow pronotal markings nearly reach the tegulae, instead of being confined to the front half; the band of the basal abdominal segment is different in form, being emarginate in the middle of its front margin, and the second is only a little widened at the sides; the legs are much more pale in colour. Structurally, the clypeus easily separates the two forms.

*Hab.* Queensland, Mackay, 1 ♀ (*Turner*).

64. *PARALASTOR EUSTOMUS*, sp. n.

♀. Nigra, clypeo utrinque late, macula elongata interantennali, parte articuli primi antennis antica, notis postorbitalibus duabus, pronoto fere toto, tegulis, fascia scutellari et postscutellari, propodeo utrinque, femoribus, tibiis tarsisque, segmento (parte magna basali declivi excepta) primo, fasciæ apicali, vix dilatata, secundi, cum segmentis sequentibus, aurantiaco-rufis. Clypeus profundissime emarginatus, emarginatione, quam semicirculus, profundiore, post hanc depressus, nitidus, punctatus, lateribus

deflexis opacis et pubescentibus. Frons capitis et thorax densius pilosi, pilis minus longis. Pronotum antice fere recte truncatum, parum distincte marginatum. Tegulæ dense minutissime punctulatæ, fere opacæ. Postscutellum medium tuberculo spiniformi armatum. Abdominis segmentum primum transversim subdepressum, haud grosse punctatum; secundum dorsale, basim versus, haud convexim elevatum; ventrale, post sulcum transversum, fortissime elevatum, fortiter nec dense punctatum. Alæ infuscatæ. Long. circiter 12 mm.

Owing to the depression of the clypeus anteriorly, behind the emargination, two blunt or rounded carinæ are formed where the sides are deflexed.

*Hab.* Australia, no special locality. Two old and dirty examples in the British Museum.

#### 65. PARALASTOR PSEUDOCROMUS, sp. n. (Pl. I. fig. 14.)

♀ colore et picturatione *P. argentifrons* Sm. ornata, et ut probabile, eodem modo variabilis; structura a *P. eustomo* vix distinguenda. Long. 10·5–12 mm.

Two long curved spots on the sides of the clypeus and the medio-frontal and postocular spots orange, those on the clypeus reduced in size and redder in one example. Pronotal spots, which are small, and the pale part of the tegulæ orange or red. Both the first and second fasciæ of the abdomen are broad and laterally dilated, the second at its middle reaching about to the middle of the segment, and towards the sides considerably nearer still to the base. The coloration is not the same as that of *P. eustomus*, but is rather that described by Saussure as "*sanguineus*." Excepting that it appears to be of rather more slender and elongate form, the species in structure is much like *P. eustomus*. Since the two examples, that I have seen, exhibit some variation, further material is necessary to decide whether the present species and *P. eustomus* are more than local colour-forms of one species.

*Hab.* Victoria (*French*); two examples.

#### 66. PARALASTOR VULNERATUS SAUSS.

This small but robust species appears to vary in the pattern of the second abdominal segment, like *P. argentifrons* Sm., or rather, I should say, like the examples I refer to that species. The clypeus may be all black, or may have small or large, orange or red, basal markings.

The extraordinary prolongation and flattening of the clypeus, with its very deep emargination, and the flattening of the plate between the antennæ to adapt it to the base of the clypeus, separate it from any other, except the following. The extremely deep and coarse puncturation of the tegulæ, the form of the insect and its sculpture, and the condition of the hind angles of the second abdominal segment, are altogether like *P. sanguineus* Sauss.,

of which I suspect it may be the female. No two of the three females are alike in detail, but the material is quite insufficient for a proper understanding of the species. The clypeus is normally extraordinarily dull, and I suspect this is due to some special excretion, as a specimen I possess shows some more shining spaces and some dull raised lumps, as if the excretion had not been distributed in the usual even manner. The scutellum is unarmed, and the second ventral segment is very strongly and abruptly raised behind the transverse sulcature.

*Hab.* Victoria, 1 ♀ (*French*); 1 ♀, without special locality, in the Oxford Museum; 1 ♀, Adelaide, in my collection.

#### 67. *PARALASTOR FALLAX*, sp. n.

♀ picturatione et colore *P. mimi* (q. v.) et *dentigeri* ornata. Clypei pars deplanata antice nigra, postice rufa. Alæ fere hyalinae, parte costali perconspicue infuscata. *P. vulnerato* structura evidenter cognatissima, sed major, clypeo nitidissimo, mesonoto magis nitido, abdominis segmento 2 dorsali, basin versus, leviter convexo, facile distinguenda. Long. 10 mm.

The markings are red, as in various other species from Western Australia, which it entirely resembles superficially. I cannot be certain whether the clypeus is always highly polished, as in the single example described, or whether it may not be sometimes dull, as in *vulneratus*, but in any case the species is easily distinguished structurally by the small convexity of the second abdominal segment, which in *vulneratus*, viewed laterally, rises convexly above the first to a distinctly more conspicuous degree.

*Hab.* W. Australia, 1 ♀ (British Museum).

#### 68. *PARALASTOR BRISBANENSIS*, sp. n.

♀. Nigra, clypeo utrinque, macula parva interantennali duabusque postocularibus, pronoto (desuper aspectu) ex maiore parte, tegulis, fascia lata scutellari, fascia postscutellari, macula utrinque mesopleurali, abdominis segmento primo (parte declivi excepta) ex maiore parte, fascia secundi segmenti minus lata, fere recta, cum marginibus posterioribus segmentorum sequentium, aurantiacis. Alæ infuscatae, parte costali saturatiore. Clypeus leviter late emarginatus, opacus, æqualiter, subtiliter punctatus, et lateribus deflexis argenteo-pubescentibus exceptis, ubique deplanatus. Frons inter antennis deplanata, clypeo quam perfectissime adaptata, spatio depresso, ocellum anteriorem includente, lineis curvatis lævibus et elevatis late marginato. Mesonotum grosse punctatum, postice tri-sulcatum, sulcis lateralibus ad pronoti marginem interiorem extensis, postscutello inermi, tegulis nitidis, sat conspicue grosse punctatis. Abdominis segmentum primum profunde, sed minus grosse, punctatum, inter puncta quam densissime punctulatum, sive granulatum. Segmentum 2 dorsale pernigrum, densissime inter puncta minutissime sculpturatum, basin versus fortiter convexum; segmentum

2 ventrale, post sulcum, fortissime elevatum, elevatione summa prominente. Long. 11.5 mm.

The clypeus is wide and much less produced than in *P. vulneratus*, and is only feebly emarginate, but it is flattened in the same perfect manner, and the front, between the antennæ, is similarly flattened. The raised smooth lines of the front of the head are found only in this and the following allied form. The femora all have a conspicuous yellow apical spot outwardly, which contrasts strongly with the ferruginous tibiæ and tarsi.

*Hab.* Queensland, Brisbane. I captured 1 ♀ on Christmas Day, 1904.

#### 69. PARALASTOR MACKAYENSIS, sp. n.

♀ structura præcedenti fere similis, sed abdomine flavo-ornato, pedibus pallidioribus, fascia prima abdominali antice sat profunde nigro-emarginata, pronoti maculis multo minoribus, scutello post-scutelloque binotatis, haud fasciatis, distinguenda.

In the very poor material at my disposal I see no structural character that could be relied on, as constant, to separate this form from the preceding, of which it is probably a more northern race. In markings and in colour of the markings the two are very distinct, the deep orange colour of *brisbanensis* being replaced by a more ochreous or pale orange in *mackayensis*.

*Hab.* Queensland, Mackay, 2 ♀ (*Turner*); 1 ♀ from the same locality from E. Saunders.

#### 70. PARALASTOR PRINCEPS, sp. n.

Niger, valde longipilosus, macula parva interantennali, duabusque minutis postocularibus, ornatus. Maculæ duæ minores pronotales, fasciæque duæ abdominales, minus latæ, aurantiacæ. ♂ clypeus cum parte articuli antennarum primi antica flavescens. Species grandis, pilis longis ubique conspicue vestita, capite quadrato-incrassato, clypeo (præcipue ♂) brevi, lato, apice truncato, pilis longis erectis conspicue vestito; clypei ♀ punctis majoribus aliisque minutis sat densis. Frons media dense rugosim sculpturata, antennis versus et in sinu oculari utroque pilis longis nigricantibus conspicue vestita. Mesonotum et scutellum quam densissime sculpturata, postscutello inermi. Abdominis segmentum primum pilis longis griseis, secundo etiam et sequentibus pilis erectis longis et conspicuis vestitis. Alæ (costali parte excepta) exemplorum recentium parum infuscatæ. Tegulæ subtiliter punctatæ, minutissime etiam punctulatæ. Abdominis segmentum 2 ventrale post sulcum suum transversum fortissime elevatum, elevatione summa prominente, pilis longissimis vestitum, segmento ♂ ultimo minutissime punctato, punctis paucis majoribus intermixtis, pubescente, et pilis erectis sparsim vestito. Femora, tibiæ tarsi que nigra, aut nigricantia, tibiis posterioribus basim versus

maculatis, pilis longis tenuibus sparsim vestitis. Long. 14-15 mm.

This large hairy species with truncate clypeus cannot be confused with any other. There is a good female in the British Museum bearing a MS. label, "*Alastor australis*," which is a smaller species with ferruginous tibiæ and tarsi, and otherwise different. There is a single male, deprived of the greater part of its antennæ, and a very old abraded female in the Oxford Museum, which have the wings more infuscate or discoloured by age.

*Hab.* W. Australia, 1 ♂, 2 ♀, as referred to above.

#### 71. *PARALASTOR SUBOLORIS*, sp. n.

Mas mari præcedentis colore, vestitu et sculptura similis, sed statura multo minore, thorace toto nigro, abdominis fascia prima latissima, partem majorem segmenti, desuper aspecti, occupante; tarsis omnibus tibiarumque apicibus testaceis, facillime distinguendus. Long. 10 mm.

Apart from the above characters, the apical ventral segment is still broader, its minute puncturation is less dense, and the few slightly larger punctures are hardly noticeable, while the second ventral segment is much more finely punctured. A single female in the British Museum may belong to this species. It lacks the minute interantennal spot of the male, but has two small prothoracic ones. Its second dorsal segment is very long and parallel-sided. It is in a dirty condition.

*Hab.* W. Australia, 1 ♂ in the Oxford Museum.

#### 72. *PARALASTOR OLORIS*, sp. n. (Pl. I. figs. 4 & 16.)

Mas mari *P. suboloris* forma, sculptura, vestitu et colore simillimus, sed minor, antennarum articulo primo nigro, tibiis tarsisque ferrugineis facile distinguendus.

A small narrow species, with the basal orange fascia deeply emarginate in front, the 2nd ventral segment with large sparse punctures, and the top of the truncation in the middle still more strongly raised and prominent than in the preceding species. The apical ventral segment is less wide, very dull from the extreme density of the sculpture, which is hardly to be distinguished as puncturation, between the fine and sparse feeble punctures, that can be distinguished as such. The clothing of this segment consists of excessively short pubescence or tomentum, long, erect hairs being absent. The second ventral segment is almost bare except just behind the tubercle, and the following ones are merely tomentose. Antennæ 11-jointed, with the three apical ones minute, as in *P. suboloris*.

*Hab.* Australia, Swan River; 1 ♂ in the British Museum.

#### 73. *PARALASTOR COMMUTATUS*, sp. n.

♀. Nigra, angustula, clypei macula basali magna, curvata, macula interantennali, duabus postocularibus minutis, pronoto

ex parte maxima, maculis 2 rotundatis scutellaribus, duabus minutis mesopleuralibus, fascia latissima segmenti 1 abdominalis, fascia secundi fere recta et, quam fascia prima, multo minus lata, tibiis tarsisque omnibus, rufescentibus. Clypeus truncatus, ex majore parte dense, subtiliter ruguloso-punctatus. Mesonotum posterius irregulariter aut vix dense punctatum, postscutello inermi. Tegulae vix nitidae, ex majore parte subtilissime, vix evidenter sculpturatae, puncturatione minutissima distincta carentes. Abdominis segmentum primum haud fortissime transversum, parte declivi excepta fere totum rufum; secundum elongatum, lateribus fere parallelis, basi haudquaquam convexim elevata. Segmentum 2 ventrale post sulcum fortissime elevatum, elevatione summa fortissime prominente, tuberculum fortem formante. Long. 9 mm.

I have seen only a single female of this distinct species and it is in dirty condition. The wings appear to be infuscate, but this may be partly due to this condition. In any case the costal portion is much darker than the rest.

*Hab.* Australia, Champion Bay; 1 ♀ in the British Museum.

#### 74. PARALASTOR CARINATUS Sm. (? LATERITIUS Sauss., var.).

I have before me a single female from the Oxford Museum, which I refer, as a slight variety, to this species. It has a pair of small orange basal spots on the clypeus, and the black colour of the second abdominal segment is more extensive, forming a basal band, angulated in the middle and with irregular sinuations on each side of this. The clypeus is truncate, punctate, and more or less strigose, turned upwards on its apical portion, and with a fovea in the middle adjoining the apical margin. There is in some aspects a faint trace of tuberculation in the middle line of the postscutellum. The second ventral segment is very strongly raised behind the transverse sulcature, and somewhat pointedly produced in the middle at the top of the truncation; it is rather finely and not very unevenly punctured, with very distinct interstitial minute puncturation.

*Hab.* Adelaide, 1 ♀, Oxford Museum. The type is in the British Museum and must nearly, if not altogether, agree with the Oxford specimen, except in slight points of colour, which vary similarly in other species.

#### 75. PARALASTOR VIDUUS, sp. n.

♂. Niger, clypeo, articulo antennarum primo antice, maculisque 2 postocularibus, flavis. Pronotum colore aurantiaco-flavo bimaculatum, scutello minute binotato. Abdominis segmenta 2 basalia sat late aurantiaco-fasciata, segmentis nonnullis sequentibus etiam fasciatis. Clypeus nitidus, late truncatus, minus inaequaliter punctatus, pilis erectis, aut suberectis, pallidis vestitus. Frons cum thorace pilis longis subfuscis conspicue vestita. Pronoti truncatio evidenter marginata. Tegulae nitidae,

ex maxima parte vix punctatæ. Postscutellum inerme. Abdominis segmentum primum transversum depressum, margine posteriore elevatulo, medium subfoveatum, puncturatione confusa; secundum dorsale pilis parvis longis erecte vestitum, fortissime convexim elevatum; ventrale, post sulcum suum, fortiter elevatum, elevatione summa haud prominente, cum sequentibus hirsutissimum, segmento ultimo pilis erectis brevioribus sat dense vestito. Antennæ fortiter clavatæ, 12-articulatæ, articulis 4 ultimis parvis. Long. circiter 11 mm.

*Hab.* Victoria, 1 ♂ (*French*). The specimen bears several labels: "C.F. 8.00"; "Macedon 1.3.93"; "Melbourne, Victoria."

#### 76. PARALASTOR ODYNERIPENNIS, sp. n.

♀ colore fere præcedentis, sed clypeo nigro, ad basim flavo-aurantiaco-maculato, scutello et antennis nigris, tibiis nigricantibus, tarsis ex majore parte atro-brunneis.

Structurally this appears to me to be almost identical with *P. carinatus*, but the dark legs (the hind tibiæ inwardly at the base being rufescent) easily distinguish it. The second cubital cell is triangular and not at all petiolate. The second abdominal fascia does not occupy half the length of the segment.

*Hab.* Victoria (*French*).

#### 77. PARALASTOR ODYNEROIDES, sp. n.

♂ colore *P. vidui*, sed macula interantennali elongata flava, scutello nigro, maculis pronotalibus minutioribus aurantiacis, distinguendus. Structura valde distinctus. Clypeus fere recte truncatus, medius depressus, utrinque quasi rotundatim carinatus, obscure punctatus. Mesonotum grosse punctatum, postscutello inermi, tegulis nitentibus, ex majore parte obsoletissime minutissime punctulatis. Abdominis segmentum primum fortiter transversum, rugosissime grosse punctatum, parte declivi media longitudinaliter carinata. Segmentum 2 dorsale fortiter basim versus convexim elevatum, fascia utrinque ante medium segmentum extensa, profunde rotundatim antice emarginata, segmentis cæteris aurantiacis. Segmentum 2 ventrale post sulcum fortiter abrupte elevatum, elevatione summa subangulatim producta; segmentum ultimum fortiter convexum, pilis erectis vestitum. Antennæ 11-articulatæ, articulis 3 ultimis minimis. Cellula 2 cubitalis haud petiolata. Long. circiter 11 mm.

*Hab.* Australia; 1 ♂ in the Oxford Museum.

#### 78. PARALASTOR MUTABILIS, sp. n. (Pl. I. fig. 8.)

♀. Nigra, clypei macula basali transversa, antice emarginata, duabus minutis postocularibus, duabus pronotalibus, tegularum parte exteriori, fascia lata abdominalis segmenti primi, antice emarginata, fascia secundi, aut fere simplici, aut utrinque valde

dilatata, et fere ad basim segmenti extensa, rufis aut rufescentibus. Clypeus latus, truncatus, subæqualiter punctatus, et minutissime punctulatus. Mesonotum crebre fortiter punctatum, scutello inermi, tegulis nitidis, punctis majoribus nonnullis, parum fortiter impressis, præsentibus. Alæ infuscatæ, parte costali saturatiore. Abdominis segmentum secundum dorsale ad basim subfortiter convexum; ventrale, post sulcum, sat abrupte elevatum, parte antesulcali parti postsulcali altitudine subæquali, elevatione summa haudquaquam prominente. Long. 9-10 mm.

With this species begins a series of forms with the hind part of the second ventral segment raised only to about the height of the basal portion, and with the clypeus always truncate apically.

*Hab.* Victoria (*French*); 2 ♀, Sept. 1901. The two examples have a quite different pattern of the second abdominal segment, and they are in a dirty condition.

#### 79. PARALASTOR PLEBEIUS, sp. n.

♀. Nigra, macula clypei curvata basali, notis 2 postocularibus, duabus maculis pronotalibus, nonnunquam notis 2 scutellaribus, margine postico segmentorum 2 basaliū abdominis angustius, flavis. Clypeus truncatus aut paullo antice rotundatus, fortiter æqualiter punctatus. Frons capitis cum mesonoto dense punctata, pilisque brevioribus sat crebre vestita, scutello inermi. Tegulæ nitidæ, parum distincte sculpturatæ. Abdominis segmentum primum fortiter transversum; secundum ad basim fortiter convexum, pilis erectis brevioribus ubique, nec dense, vestitum; secundum ventrale, ut in præcedente formatum. Alæ fusco-hyalinæ, parte costali multo magis infuscata. Tibiæ tarsique rufescentes. Long. 9-10 mm.

*Hab.* Adelaide, 1 ♀, British Museum; 1 ♀, Oxford Museum; Victoria (*French*), 1 ♀.

#### 80. PARALASTOR SUBPLEBEIUS, sp. n. (Pl. I. fig. 15.)

♀ præcedenti cognatissima, sed major, fasciis abdominalibus minus angustis, flavo-aurantiacis, segmento primo abdominis conspicue transversim depresso, facile distinguenda. Long. 12 mm.

This is probably the representative in Queensland of *P. plebeius*, but, apart from colour, the form of the basal abdominal segment is too distinct to permit the two to be considered as varieties of one species.

*Hab.* North Queensland (*Dodd*), 2 ♀.

#### 81. PARALASTOR DEBILITATUS, sp. n.

Color fere *P. pusilli* Sauss. et *P. simulatoris* mihi. Fasciæ abdominales bicolores, antice rufescentes aut subaurantiæ, postice flavæ. ♂-clypeus flavus, ♀ parte posteriori sola flava

aut aurantiaca. Antennarum articulus primus ♂ antice flavus, ♀ aut plus minus rufescens aut totus niger. Maculae pronotales bicolores. Scutellum saepius binotatum, tegulis subtestaceis. Tibiae tarsique rufescentes. Species parva, angusta, clypeo et segmento 2 ventrali ut in spp. precedentibus formatis, forma gracillimi facile distinguenda. Long. 7-8 mm.

In this and the three preceding species the antennae are very clavate, the fifth joint being wider than long and the following becoming still more transverse. The males, except that of *P. debilis*, are not known. In this male the antennae are very strongly clavate, the fifth joint not longer than its apical width, the sixth and seventh strongly transverse. In all there are twelve joints, the three apical ones recurved to form a small hook, the preceding one being larger, but small. The wings are nearly hyaline, except along the costa, in one example, darker in the others, which are in abraded condition. One example in the Oxford Museum bears a MS. name, "*Alustor pusillus* Sauss.," but this is clearly an error.

*Hab.* Victoria (*French*), 2 ♀, in the British Museum; 1 ♂, Adelaide (*Wilson*), and 1 ♀ without locality, Oxford Museum.

## 82. PARALASTOR BRUNNEUS SAUSS.

With this species is begun a short series of allied species, which are quite distinct from any others by the form of the second ventral segment, which, behind the longitudinally costate sulcature, rises very obliquely from this to a height not, or but little, exceeding the level of the base of the segment. The clypeus is always very distinctly emarginate and plentifully and coarsely punctate, the punctures in the male being, however, more feebly impressed than in the female. The tegulae, over at least a considerable part of their surface, always bear coarse punctures, the puncturation being frequently rugose, but owing to the generally pale colour of the surface, the puncturation is usually less conspicuous than it would be were the tegulae dark in colour.

*Hab.* Australia, 2 ♀ and the type in the British Museum (*Hunter*).

## 83. PARALASTOR MULTICOLOR, sp. n. (Pl. I. figs. 9, 19.)

Præcedenti cognatissimus, sed paullo minor; ♀ clypeo flavo et macula verticis nigra, utrinque usque ad antennas producta, facile distinguendus. Clypeus distincte dentato-emarginatus, productus, minus latus, subgrosse, crebre punctatus, flavus. Caput cum thorace perparce, vix evidenter, pilosum. Mesonotum et scutellum densissime punctata, postscutello inermi. Abdominis segmentum primum crebre rugosum punctatum, haud transversim depressum; secundum dorsale (a latere visum) fortiter subæqualiter convexum curvatum; ventrale, post sulcum, oblique, parum fortiter, elevatum, et late subdepressum; segmentum ultimum ventrale ♂ brevissime pubescens. - Antennae ♂, ut

apparet, tantum 10-articulatæ, articulis 2 ultimis minutissimis. Long. circiter 7-7.5 mm.

The colour of this little species is variable. The colour of the whole front of the head is pale (the clypeus always yellow, but in other parts the yellow becomes partly or wholly orange), except that in the female the black of the vertex is produced down to the antennæ in two broad stripes, which sometimes become reddish towards the antennæ. In the male the black colour is prolonged downwards on each side for only a short distance, being arcuately emarginate just in front of the anterior ocellus. The posterior orbits are widely yellow or orange, and connected with this same colour of the anterior ones. Around the ocelli the vertex is black, but behind these may be either black or red. The pronotum, scutella, and propodeum (except in the posterior concavity) are for the most part yellow or orange, the pronotum sometimes more brownish or reddish posteriorly. The mesonotum may be all black or nearly all red. The second abdominal segment is more or less brown or reddish in front of the orange-yellow apical band, sometimes nearly entirely so. The basal segment is yellow or orange-yellow apically, shading into brown or reddish, black basally. The sides of the thorax may be black or red, with yellow markings. Legs all pale, usually fulvous, with bright yellow lines on the tibiæ and femora.

Very closely allied to *P. brunneus*, but the edges of the lateral deflexed parts of the clypeus are not so sharply defined, and the colour is very different.

I can only distinguish ten joints in the male antennæ, and this character may be peculiar to the group.

*Hab.* Port Darwin (*Dodd*).

#### 84. PARALASTOR ANOSTREPTUS, sp. n.

♀. Nigra, clypeo, antennarum articulis duabus basalibus, orbitis anterioribus et posterioribus (haud interrupte), macula elongata mediofrontali, a clypeo fere ad ocellum anteriorem extensa, pronoto ex maxima parte, postscutello et scutello fere totis, maculis magnis propodei lateralibus, parte magna mesopleurali, fascia latissima segmenti abdominalis primi, fascia apicali, utrinque subdilatata, secundi, cum pedibus omnibus, refescentibus. Segmentum abdominis tertium et sequentia, plus minusve colorata. Tegulæ brunnescentes, plus minus testaceæ. Clypeus fortiter rugoso-punctatus, apice producto, parum lato, subfortiter emarginatus, partibus deflexis argenteo-pubescentibus, utrinque in parte apicali subcarinatus. Frons densissime rugoso-punctata, pilis brevissimis vestita. Thorax haud aut vix pilosus, ubique densissime punctatus, postscutello inermi, propodei lateribus argenteo-tomentosis. Abdominis segmentum primum campanuliforme, sat longus, subdepressus, secundum densissime punctatum, ex majore parte longitudinis fere æqualiter et fortiter convexim rotundatum, apicem suum versus fortiter transversim

incrassatum, margine ipso valde abrupte dejecto. Alæ ubique fusco-nitidæ, parte costali saturatiore, basim versus subflavescente. Long. 9 mm.

*Hab.* N.W. Australia, S. Heywood I.; 1 ♀ in the British Museum.

#### 85. *PARALASTOR DYSCRITIAS*, sp. n.

♀ præcedenti forma, colore et picturatione simillima, sed abdominis segmento secundo ante incrassationem apicalem haud transversim depresso, bene distinguenda. Long. 9 mm.

Differs slightly in colour from the preceding, as follows:—The markings of the head and abdomen tend to a more orange-red colour, and those behind the eyes do not extend beyond about the middle of the length of these organs. There is a roundish mesopleural spot beneath the tegulæ and only a very small one beneath this; the tegulæ are much redder, the legs paler, more fulvous. The apical dorsal segment is concolorous with the orange ones preceding it. The third antennal joint is nearly all red (only somewhat reddish in the other). These colour-differences may be quite inconstant, but in *dyscritias* the tegulæ are coarsely rugosely punctate over nearly the whole surface, smooth, shining, and sparsely punctured over a considerable area in *anostreptus*. The actual hind margin of the second segment is more abruptly depressed in the latter, and its incrassation is raised on the basal side from the general surface of the segment, whereas in *dyscritias* it is not at all defined in front from the rest of the surface.

*Hab.* Australia, 1 ♀ in the British Museum, without locality.

#### 86. *PARALASTOR XANTHOCHROMUS*, sp. n.

♀. Nigra, clypeo utrinque, macula interantennali, antennarum articulo (ferrugineo) primo antice, maculis duabus elongatis postocularibus, duabusque in sinu oculorum sitis, duabus pronotalibus, scutellaribus, mesopleuralibus et propodealibus flavis, sive aurantiaco-flavis. Abdominis segmentum primum late flavo-fasciatum, fascia profunde nigro-emarginata; secundum cum sequentibus fascia apicali ornatum. Pedes fulvescentes, partibus nonnullis flavescentibus. Long. 9 mm.

Extremely close to the preceding in structure, but entirely different in appearance. The tegulæ have the same coarse puncturation. The clypeus is a little more strongly produced, and the front of the head rather more distinctly punctured, while the apical margin of the second dorsal segment of the abdomen is less strongly and abruptly depressed.

A single male that I possess, from Townsville, does not agree with either this or the preceding species, but is very like *dyscritias* ♀ in its markings; which, however, are orange-coloured, not red, and there is a pair of large red spots towards the base of the second ventral segment, not connected with the

apical band. The structure of the second dorsal segment apically is rather different from either species, but, in the absence of the male sex of the others, it is too close to be worth describing as distinct. This male was taken on March 15th, 1902, by Mr. F. P. Dodd.

*Hab.* Queensland, Cairns, 1 ♀.

#### 87. *PARALASTOR PICTETI* Sauss.

With this species begins a series of allied forms, forming my second division. It is Saussure's division of *Alastor picteti*, which he characterized as having the abdomen subpetiolate. All the specimens of *picteti* that I have seen come from Queensland. The details of coloration in this species vary a little, and I think none exactly agrees with Saussure's description. He gives "Tasmania" as the locality for his insect, but, as with some other species already referred to, I doubt the correctness of this. The tegulæ are for the most part smooth and polished.

*Hab.* Queensland, Bundaberg and Cairns, taken by myself; Mackay, three bad specimens (*Turner*); Kuranda, May to June, 1913, eleven examples.

#### 88. *PARALASTOR CONSTRICTUS*, sp. n.

♀. Nigra, clypei parte basali nigra, apice lateribusque flavis, picturatione variabili. Macula interantennalis, margines oculares antice posticeque plus minus—variabiles tamen sunt—pronoti fascia irregularis anterior, ad tegulas lineatim utrinque producta, maculæ scutellares, postscutellares, propodeales et mesopleurales, segmentum abdominale (parte declivi excepta) ex maiore parte primum, fascia secundi lata cum duabus maculis magnis basalibus, et segmentorum fasciæ sequentium, aurantiaca. Pedes fulvescentes, femorum parte apicali sæpe flavo-notata. Antennarum articulus primus antice flavescens aut fulvus, flagello sæpe subtus rufescente. Clypeus truncatus aut vix emarginatus, margine apicali recto aut perpaullo concavo, fortiter punctatus, puncturatione minuta interstitiali distinctissima. Frons cum thorace pilis erectis brevioribus subcrebre vestita, capite densissime punctato. Mesonotum densissime grosse punctatum, puncturatione distinctissima, sed subrugosa. Alæ subhyalinæ, costali parte fusco-flavescente, stigmate pallido, cellula marginali infumata. Tegulæ ex magna parte læves, politæ. Abdominis segmentum primum grosse, sæpe rugose punctatum, parte basali segmenti secundi remote aut irregulariter punctata. Long. 9–11 mm.

I have seen only five examples of this species and no two are alike in details of markings or sculpture, but I think they certainly all belong to a single species.

*Hab.* Queensland, Bundaberg, 2 ♀, taken by myself (June 1904); 1 ♀, Queensland (*ex coll. E. Saunders*); Mackay (*Turner*), 2 ♀.

In one of my Bundaberg examples the orbits are entirely

black, in the other they are yellow from the clypeus to the middle of the ocular sinus; in Saunders's example they nearly connect with the postocular orbital stripes.

89. *PARALASTOR MESOCHLORUS*, sp. n.

♀ præcedenti cognatissima, sed pronoti maculis haud ad angulos humerales extensis, segmento 2 abdominalis ad basim nigro, aut tantum maculis rufescentibus ornato, colore primi læte aut pallide flavescente, distinguenda. Long. circiter 9 mm.

This species is again variable, and there are evidently two distinct forms of it, but the material is far too poor for a proper understanding either of its definite specific characters or of its variation. Of the typical form there are 2 males and 1 female.

In the female the clypeus is almost truncate, red at the apex and along the sides, the antennæ are red beneath, infusate above, the scape and following joint less so than the others. There is a yellowish interantennal spot and a small orange one behind the eyes. The pronotum is red-marked in front medially and this colour extends back to the tegulæ very narrowly as a sutural line. The scutellum, postscutellum, and propodeum have large red markings, the tegulæ are reddish brown. Basal abdominal segment above bright (slightly orange) yellow. Second with a dull orange band not occupying one-fourth of the segment, the following ones also with apical bands. Hind tibiæ dark at the apex, at least inwardly. Mesopleura with a red spot.

Clypeus of the male lightly emarginate, yellow, becoming reddish basally at least in the middle, otherwise the head coloured much like that of the female. Pronotum with red markings, produced to the humeral angles and along the suture to the tegulæ. The other thoracic markings are like those of the female, but bright yellow, a little orange-tinted, nearly concolorous with the basal abdominal segment; second segment either all black or coloured much as in the female, the basal spots reddish or brownish, if present.

*PARALASTOR MESOCHLORUS MESOCHLOROIDES*, st. n.

Female clypeus as in the preceding, but the coloured parts are yellow or partly yellow. Inner orbits with a yellow line from the clypeus extending into the sinus. Pronotum only with two obscure spots or faintly reddish on the suture medially. Thoracic markings bright lemon-yellow, the black median part of the propodeum less wide than in the male of the preceding, which these females resemble in appearance. Basal abdominal segment nearly concolorous with the thoracic markings. Second all black, the apical margin at most obscurely paler. Tegulæ bright yellow inwardly, and at the point of their deflexion less coarsely and deeply punctured than in the preceding form. Male not known.

*Hab.* Queensland, Mackay, 2 ♂, 1 ♀ typical form, in Sept. and Oct. 1899 (*Turner*); race *mesochloroides*, 2 ♀ at Kuranda, Feb. and April, 1902 (*Turner*).

90. *PARALASTOR DARWINIANUS*, sp. n.

♀. Nigra, clypeo cum parte mandibularum basali et antennarum articulo primo antice, macula mediana post clypeum, fere ad ocellum anteriorem extensa, orbitis interioribus et posterioribus (haud una conjunctis), fascia transversa pronotali, ad tegulas lineatim postice producta, utrinque dilatata, fere ad mesopleura producta, macula mesopleurali, tegulis thoracem versus, lineis duabus mesonotalibus elongatis, maculis 2 scutellaribus, postscutellaribus et propodealibus, margine postico sat late segmentorum abdominalium, flavis. Antennæ cum parte majore pedum brunnescentes. Abdominis segmentum primum et secundum brunnea, plus minus atrofusca. Clypeus latus, minus fortiter productus, nitidus, subtiliter punctatus, apice emarginato, margine elevatulo. Frons cum thorace breviter erecte pilosa. Mesonotum distincte, vix dense punctatum. Abdominis segmentum primum haud ubique densissime punctatum, medium subfoveatum. Alæ subfuscae, nitentes, stigmate pallido. Tegulae laeves, nitidissimae. Long. vix 10 mm.

A very distinct species. The yellow colour of the inner orbits curves round on each side behind the ocelli, but the extremities do not meet, and are well separated from the broad postocular stripes.

*Hab.* Port Darwin, 1 ♀ (*Dodd*).

91. *PARALASTOR COMPTUS*, sp. n.

♂. Niger, clypeo, macula mediana excepta, mandibularum parte basali, macula elongata frontali, orbitis interioribus ad sinus oculorum et sinibus ipsis, macula parva verticali oculos juxta, orbitis posterioribus lineatim ex majore parte, pronoti margine antico, macula mesopleurali, tegulis ex magna parte, maculis duabus scutellaribus, postscutellaribus et propodealibus, margine postico segmentorum 2 basaliū abdominis, tibiæ omnes externæ, et parte exteriori femorum intermediarum, flavis. Antennarum flagellus subtus fulvescens, supra infuscatus, rufo-tinctus. Stigma alarum atrum. Clypeus distinctissime angulatim emarginatus, punctis majoribus sparsissimis, albo-pubescentis. Mesonotum cum scutello profunde grosse punctatum, punctis inter se distinctissimis. Tegulae ex majore parte laeves et politæ. Postscutellum cum propodeo distincte et profunde punctatum, punctis quam mesonotalibus paullo minus grossis. Abdominis segmentum primum grossissime punctatum. Segmentum 2 ventrale post sulcum late depressum, depressione antice elevato-marginata, segmento ultimo pilis sparsis erectis longioribus vestito. Long. 7-8 mm.

Var. *RUBESCENS*, nov.

Pronotum ex majore parte et pars mesonoti media late, rufescentia. Fascia prima abdominalis vage rufo-marginata. Segmentum secundum atrofusca.

I have seen only two males of this species, differing greatly in colour, as above described. The antennæ are 11-jointed, the three apical ones very minute, and difficult to see in my specimens, being sunk in the apical cavity of the eighth joint.

*Hab.* North Queensland, Herberton (*Dodd*).

92. *PARALASTOR ALEXANDRIÆ*, sp. n. (Pl. I. figs. 7, 22.)

With this species begins a small series of forms, distinguished at once from any of the preceding by the sculpture of the tegulæ, which are either densely minutely punctured over nearly all their surface or bear coarse and conspicuous punctures, with evident fine ones between these, towards the outer margin on the anterior part.

Brunneus, capitis vertice, nonnunquam etiam fronte, et rarius parte mesonoti antica, nigris. Clypeus ♂ totus, ♀ utrinque, macula interantennali, orbitis internis et externis (nonnunquam vix interrupte), maculis duabus pronotalibus, mesopleuralibus, scutellaribus, postscutellaribus et propodealibus cum majore tegularum parte, albo-flavis. Segmenta 2 basalia postice albido-flavo marginata, fascia prima lata, segmentis sequentibus etiam plus minusve fasciatis. Antennæ subtus plus minus rufescentes, articulo primo sæpe antice albido-flavo, aut toto ferrugineo, aut supra nigrescente, colore variabili. Alæ hyalinæ, parte costali plus minus infuscata, cellula marginali ex majore parte infuscata. Tibiæ omnes cum femoribus anterioribus et intermediis albido-lineatæ. Clypeus distincte emarginatus, ♀ remote punctatus, interstitiis minutissime punctatis, ♂ obscure punctatus, punctis sat magnis, sed levissime impressis, ubique albo-pubescentis. Caput cum thorace tomentosus, hoc pilis erectis perpauca aut nullis vestito. Mesonotum postice sparsim aut irregulariter punctatum, superficie interstitiali conspicue minute punctata. Tegulæ crebre et minutissime punctatæ. Abdominis segmenti secundi margo apicalis fortiter depressus, latus; segmentum 2 ventrale antice grosse, postice subtilius, punctatum. Long. 7·5–9 mm.

*Hab.* N. Australia, Alexandria, Dec. 1905, 2 ♀, January, 1907, 1 ♂ and 1 ♀ (*W. Stalker*); Adelaide River, 2 ♀: all in the British Museum.

93. *PARALASTOR ARENICOLA*, sp. n.

♀. Caput nigrum, clypeo rufescente, utrinque flavescente; lineis orbitalibus, in sinum oculorum a clypeo productis, maculaque interantennali, flavescentibus, lineis postorbitalibus usque ad verticem capitis extensis. Pronotum rufescens, antice albido-flavo aut aurantiaco-flavo colore variegatum; mesonotum nigrum, plus minusve rufo-suffusum aut rufo-notatum; scutellum, margine antico excepto, cum postscutello rufescente, ambobus flavo-binotatis. Propodeum rufescens, latera versus nonnunquam flavescentis. Mesopleura macula flavescente ornata, rufescentia aut nigro-variegata. Pedes rufescentes, tibiis albido-flavo lineatis. Abdomen

rufescens, segmento primo ante fasciam apicalem, latam, albido-flavam, nonnunquam nigro, secundo fascia fere simplici lata ornato, maculaque utrinque magna basali, pallide flava aut albida decorato. Clypeus levissime, sed sat distincte, emarginatus. Long. 7.5 mm.

Allied to the preceding, with generally similar sculpture and the apical margin of the second abdominal segment similarly depressed and wide. Easily distinguished by the fairly numerous and conspicuous large punctures of the tegulæ, and the rougher postscutellum, which is rather differently formed.

*Hab.* Central Australia, Hermannsburg, 2 ♀ (*H. J. Hillier*). The specimens are not in very good condition, the one which is not mutilated being probably somewhat discoloured.

#### 94. PARALASTOR SIMILLIMUS, sp. n.

Picturatio et color fere *P. constricti* (q. v.), sed statura minore. Clypeus ♂ flavus, ♀ macula parva nigrescente signatus, apice truncato, aut vix evidenter emarginato.

♀ clypeo obsoletius punctato (sc. punctis parum fortiter impressis), antennis crassioribus, tegulis opacis aut vix nitidis, punga grossiora ferentibus, distinguenda. Long. 8 mm.

As the female of this species is unique and the male of *P. constrictus* is unknown, I have only been able to compare this female example with the latter species, and unfortunately I do not feel quite sure that this single female belongs to the males that I assign to *simillimus*. On account of the better material, I have taken a male as the type and not this unique female. It lacks the pair of large basal spots on the second abdominal segment at the base and the tegulæ are less punctured than in the male. Seen in profile, the second segment is much more evenly rounded above than in *P. constrictus*, and this is also, to a less extent, true of the male.

The male has the tegulæ very coarsely punctured over nearly the whole surface, the clypeal punctures are feebly impressed and the apex of the clypeus is truncate or almost so. The general sculpture is nearly the same as that of *constrictus*. The second ventral segment is not flattened or slightly depressed behind the transverse sulcus as it is in *constrictus*. The apical ventral segment has a very short pubescence, which is decumbent or sub-decumbent.

The species is quite distinct, and it is highly probable that the sexes are correctly associated.

*Hab.* Queensland, Mackay (*Turner*), 1 ♂, 1 ♀. I took the former sex at Bundaberg, but no ♀.

#### 95. PARALASTOR SYNCHROMUS, sp. n.

Picturatio *P. constricti* picturationi fere similis, sed ♀ clypeo rufo, basin versus utrinque flavo-ornato, pronoto, desuper aspecto, ex majore parte aut ubique colorato, rufo flavoque colore variegato, scutello postscutelloque flavo-fasciatis (illo haud maculis bene

separatis ornato), fasciis integris, aut vix interruptis, maculis propodealibus rufis aut flavo-rufis, segmento 2 abdominali maculis basalibus carente, distinguenda. ♂ ♀ tegulis minutissime evidenter punctulatis et clypeo distinctissime emarginato, facile distinguendi; a *P. similino* clypeo distincte emarginato, primo aspectu separandi. Long. 8-9.5 mm.

The apical margin of the second abdominal segment is quite strongly depressed and rather wide; ventrally behind the sulcation it is depressed, and very remotely punctured. The apical ventral segment of the male is subconvex and clothed with erect, but not long, hairs.

*Hab.* Queensland, Mackay, ♂ ♀, 6 examples (*Turner*); Bundaberg, 1 ♂, 1 ♀, and Cairns, 1 ♀, taken by myself.

#### 96. *PARALASTOR LEPTIAS*, sp. n.

Clypeus ♂, macula interantennalis, linea orbitalis sinum oculorum intrans (nonnunquam ex parte oblitterata aut rufescens), antennarum articulo primo ♂ antice, plerumque pallide flavescencia aut albo-flava. Pronotum ex magna, aut ex majore parte, scutellum et postscutellum maculatum, propodeum latera versus, rufescencia, hic illic flavo-variegata. Tegulae plus minusve flavo-notatae. Abdominis segmenta 3 aut 2 flavo-albido marginata, fasciis his antice rufo-variegatis. Pedes colore variabiles, rufescentes plus minus flavo-albido-variegati, femoribus posterioribus plerumque nigris. Mandibulae rufescentes, ♂ albido-notatae. Clypeus ♀, et antennarum articulus primus antice, rufescentes, illo plerumque utrinque albido-maculato. Clypeus ♂ saepe plus minus antice rufo-notatus. Mesopleura rufo-maculata, macula nonnunquam plus minus flavescencia. Ala, costali parte excepta, parum infusata.—Species elongata, gracilis, abdominis segmento primo campanuliformi, secundo elongato, angusto, lateribus subparallelis, basim juxta angustatis. Clypeus subfortiter emarginatus. Caput cum thorace pilis brevioribus erectis vestitum. Mesonotum et scutellum grosse, distincte punctata, puncturatione mesonotali postice irregulari aut minus densa. Abdominis segmentum ventrale ♂ apicale pilis brevissimis vestitum, leviter convexum. Antennae ♂ 11-articulate, articulis 3 ultimis minimis, in concavitate articuli 8 receptis. Long. 7.5-8.5 mm.

On account of its very narrow second segment of the abdomen, this species appears rather out of place in this division, the first segment appearing less small in comparison with the hinder parts. It varies a good deal in details of coloration, the second abdominal segment sometimes having two conspicuous rufescent basal spots and sometimes lacking these. The lines along the outer orbits are usually distinctly bicolorous, and are abbreviated in some specimens. The tegulae have a minute and plentiful puncturation, and generally a few larger, but feeble, punctures are noticeable.

*Hab.* Adelaide; collected for me by some of the late T. B. Blackburn's pupils.

97. *PARALASTOR IGNOTUS*, sp. n.

♂. Clypeus, antennarum articulus primus antice, pronotum, tegulæ, macula mesopleuralis, scutellum postscutellumque et propodeum utrinque, aurantiaco-flavescentia. Abdominis segmentum primum, plaga nigra basali excepta, cum pronoto fere concolor, secundo fascia simili, irregulari, apicali, duabusque maculis basalibus obscurioribus, ornato. Pedes ex majore parte aurantiaco-flavescentes, femoribus posterioribus nigris. Stigma alarum atrum. Antennarum articulus 8 plus minus rufescens. Clypeus subfortiter dentato-emarginatus, subcrebre punctatus, dense argenteo-pubescent. Mesonotum fortiter punctatum, nitidum. Abdominis segmentum ultimum ventrale pilis erectis, sat conspicuis, densius vestitum, subtilissime distincte punctatum. Tegulæ nitidæ, puncturatione minuta distincta, paucis punctis majoribus præsentibus. Long. circiter 9 mm.

*Hab.* Australia, Swan River, 1 ♂.

98. *PARALASTOR ICARIOIDES*, sp. n. (Pl. I. fig. 2.)

Colore et picturatione fere *P. mesochloro* var. *mesochloroidei* assimilis, maculis scutellaribus, propodealibus et postscutellaribus cum abdominis segmento primo citrinis, sed tegulis minute et copiose punctatis facillime distinguendus.

This species varies in details of coloration, the pronotum above being sometimes nearly all red, sometimes only spotted with red in front, and may have two quite distinct yellow spots in the red colour. The clypeus may be entirely yellow in the male or yellow only at the base, the rest being reddish or brownish red. In the female it is usually red, sometimes, however, more or less yellow at the sides towards the base. The inner orbits may be yellow or red, or with the markings wanting. The second abdominal segment is all black or may become piceous along the apical margin, or with a brownish apical fascia. The wings are yellowish along the costa, the marginal cell conspicuously infumate, the stigma pale. The apical margin of the second abdominal segment is strongly depressed, the flattened margin wide. Antennæ brown, often paler beneath, sometimes nearly wholly fulvescent, the scape yellow in front in the male. Length 7-9 mm.; the former measurement from a small male.

I have examined fourteen examples. The species is quite distinct from *P. mesochlorus* by the different scutellum, apart from the tegular sculpture.

*Hab.* Queensland, Townsville (*Dodd & Stalker*); Kuranda near Cairns (*Turner & Dodd*); Cairns, taken by myself.

Species quæ sedis incertæ sunt, aut haud supra enumeratæ.

I have in the first part (*q. v.*) of this paper suggested the probable position of some of the following species or otherwise referred to them:—

99. *P. AUSTRALIS* Sauss.

*Hab.* Australia.

100. *P. CRUENTATUS* Sauss.

*Hab.* Australia.

101. *P. GRÆFFEL*.

*Hab.* Fiji; Ovalau.

102. *P. SMITHI* Sauss.

*Hab.* Australia.

103. *P. HIRTIVENTRIS* Cameron.

*Hab.* New Guinea.

104. *P. ABNORMIS* \* Bingham.

*Hab.* W. Australia.

#### PSEUDOZETHUS, gen. nov.

♂. Clypeus transversus, subrotundatus, clypeo generis *Ischnocæliæ* fere similis. Mandibulæ breves, robustæ, apice obliquo, dentibus 4 armato, dentibus 2 intermediis minoribus. Palpi maxillares 6-articulati, articulis 4 basalibus haud multo longitudine inæqualibus, his omnibus sat fortiter elongatis, articulo quarto duobus ultimis, una conjunctis, vix brevior. Ligula sat elongata, haud setosa, quam mentum circiter bis longior. Palpi labiales 4-articulatæ, articulo primo gracili, perlongo, apice dilatato, quam secundum (quod elongatum est, et sat robustum), multo longiore; articulis 2 ultimis elongatis, gracilibus, subæqualibus, una conjunctis secundo vix longioribus. Antennæ 13-articulatæ, articulo ultimo unicum fortem formante. Pronotum ad truncationem suam emarginatum, angulis distinctis, margine acute elevato. Postscutellum postice truncatum, desuper visum postice emarginatum, angulis lateralibus conspicue productis. Propodeum medium impressum et profunde foveolatum, impressione angustula, lateribus suis rotundatis. Abdomen ut in nonnullis speciebus generis *Zethi* formatum (cf. *Z. cæruleipennis* F.). Segmenti primi pars pedicellata sat elongata; pars postpetiolaris subglobosa, aut valde supra convexa, ante marginem apicalem profunde transversim sulcata. Segmentum secundum longe campanulatum, basi valde constricta, quasi breviter pedicellata.

Tibiæ intermediæ duobus calcaribus distinctis instructæ. Alarum cellula 2 cubitalis supra brevissime petiolata. Hoc excepto, neuratio fere *Ischnocæliæ*. Tarsorum ungues bifidæ.

♀ incognita.

\* I have recently been able to examine this species. Bingham's remarks (Tr. Ent. Soc. 1912, p. 381) on the antennæ are incorrect. In the examples he described, a moderately strong lens shows the antennæ to be normal for *Paralastor*, i. e. 11-jointed. The species should be placed next to *P. orientalis*.

*PSEUDOZETHUS AUSTRALENSIS*, sp. n.

Niger, clypeo, linea mandibulari, articulo antennarum primo, pronoti fascia transversa, tegulis, maculis scutelli duabus, spinis postscutellaribus, tibiis, tarsis, femorumque apicibus, fascia lata postpetiolaris et margine apicali segmentorum sequentium, coloratis, partibus nonnullis colore flavo-aurantiaco, nonnullis rufo decoratis. Thorax sat nitidus, grosse punctatus, propodeo rugosum punctato et opaco. Abdominis pars postpetiolaris segmenti primi fortiter punctatus, sulco apicali trifoveato. Segmentum secundum fusco-tomentosum, medium juxta marginem apicalem foveatum, subtilius remote punctatum, fascia apicali circa partem quintam segmenti occupante. Alæ flavo-hyalinæ, costam juxta flavescentes. Long. 13 mm.

The clypeus and the mandibular lines are orange-yellow, the other markings orange-red or red. The third abdominal segment is less distinctly foveate at the middle apically than the preceding one. Allied to *Elimus*, but the spinose angles of the postscutellum and the *Zethus*-like form of the basal abdominal segment are very distinctive.

*Hab.* N. Queensland, Australia (*F. P. Dodd*).

*RHYNCHIUM AUSTRALENSE*, sp. n.

♂. Aurantia flavo-flavum, clypeo, et antennarum articulo primo antice, flavis. Propodeum abdominisque segmenta 2 basalia nigra aut nigricantia. Margo apicalis segmenti primi obscure, secundi late, aurantiacus. Pedes posteriores ex majore parte nigre. Alæ flavescentes, apicibus late nigris. Apex clypei levissime emarginatus, utrinque subcarinatus. Mesonotum minus grosse punctatus, postice læve et impunctatum; scutellum impunctatum; propodeum rugosum, lateribus spinosis, concavitate sua ex majore parte lævi et nitida, postice transversim oblique rugosa. Abdominis segmentum primum remote subtilius punctatum, secundum similiter punctatum, fascia aurantia partem circiter dimidiam apicalem occupante; segmentum apicale ventrale, basi excepta, pilis longioribus erectis vestitum.

Long. 14 mm. ♀ incognita.

In the single example examined, the propodeum is tinged with red at the sides, the mesosternum and the larger part of the mesopleura are black.

*Hab.* North Queensland (*Dodd*).

*ABISPA MEADE-WALDOENSIS*, sp. n.

Almost exactly resembles in appearance the giant *Odynerus*, or more probably *Rhynchium*, described as *Abispa paragioides* by Meade-Waldo, but is a true *Abispa*, excessively close to *A. ephippium* and perhaps only a local race of this. I can see no structural difference other than may well be individual. The

whole thorax above and beneath is brownish red, the pronotum, scutella, and propodeum laterally orange. The tomentum of the mesonotum is pale, not black as in other species. Abdomen as in *A. ephippium*. Length 24 mm.

*Hab.* Port Darwin (*Dodd*).

#### EXPLANATION OF THE PLATE.

- Fig. 1. Part of 1st and 2nd abdominal segments of *P. parca* Sauss., in lateral aspect. 1 d. 1st dorsal segment; 2 d. 2nd dorsal; 2 v. 2nd ventral.
2. Part of the first and the following segments of *P. icarioides* P. The third and fourth segments were withdrawn within the second.
3. Part of first and second abdominal segments of *P. tuberculatus* Sauss., in lateral aspect.
4. Median longitudinal section of the 2nd ventral segment of *P. oloris* in lateral aspect (diagrammatic).
5. The same of *P. tricolor* P.
6. The same of *P. solitarius* P.
7. The same of *P. alexandriæ* P.
8. The same of *P. mutabilis* P.
9. The same of *P. multicolor* P.
10. Apex of clypeus of *P. imitator*, very lightly emarginate.
11. The same of *P. dentiger*, somewhat strongly emarginate.
12. The same of *P. optabilis* (clypeus quasi tri-dentatus).
13. The same of *P. atripennis* (also quasi tri-dentatus).
14. The same of *P. pseudochromus* (clypeus fortissime emarginatus).
15. The same of *P. subplebeius*; clypeus truncate, but slightly rounded.
16. The same of *P. oloris* (clypeus recte truncatus).
17. The five apical joints of the antennæ of *P. punctulatus* ♂.
18. The small 9th, 10th and 11th antennal joints of *P. hilaris*, and the apical portion of the 8th, in the terminal cavity of which the others lie.
19. Three terminal joints of *P. multicolor*, the two latter very small and lying in the apical cavity of the 8th.
20. Tegula of *P. debilis*, showing the coarse puncturation of its outer portion.
21. The same of *P. orientalis*. The coarse punctures are not equally numerous in all examples, but the sculpture is very different from that of species which have the tegulæ very minutely punctured.
22. The same of *P. alexandriæ*. The other parts of the tegulæ are, of course, sculptured, but only that part (or some of that part) which gives the best specific characters in different species is shown in this and the preceding figures.





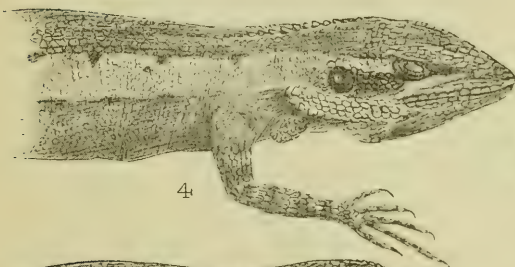
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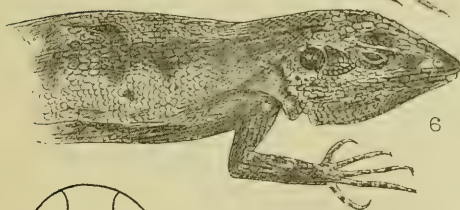
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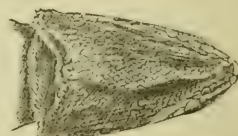
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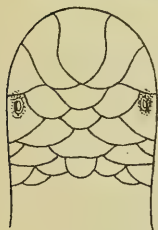
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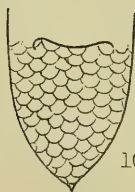
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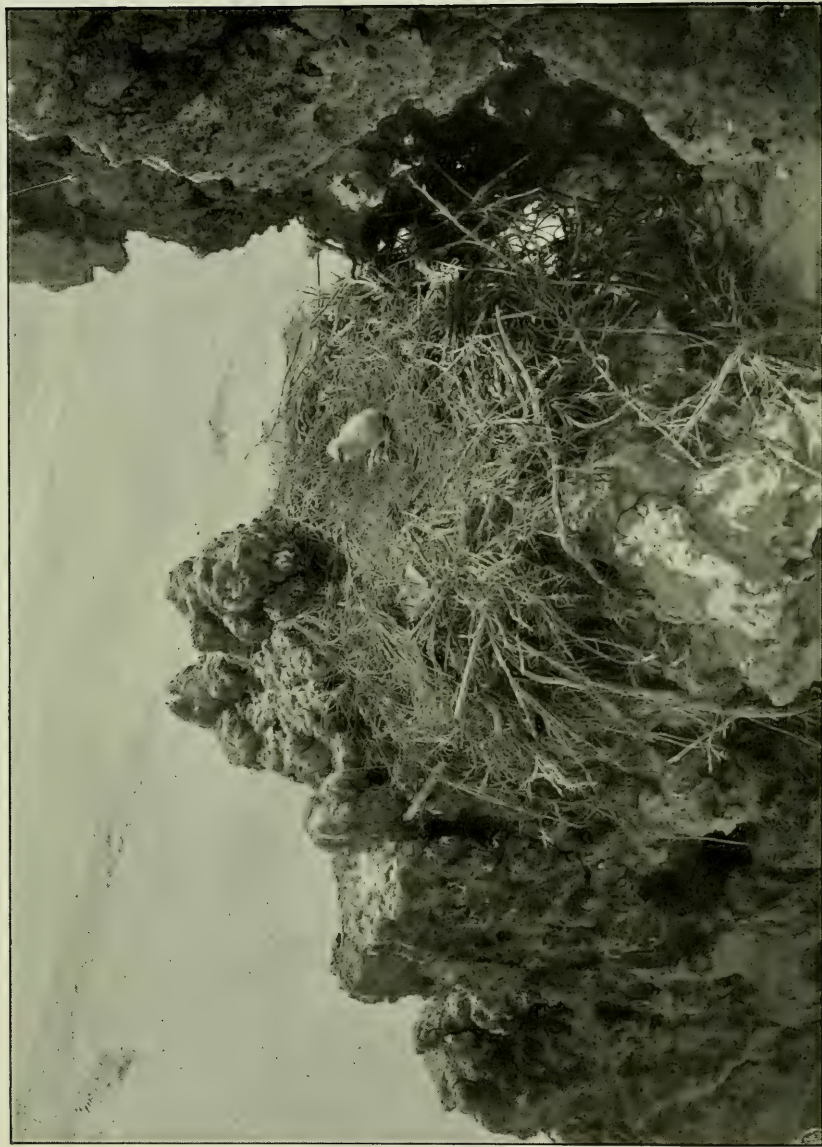




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YOUNG PANDION HALIAËTUS MELVILLENSIS IN NEST.

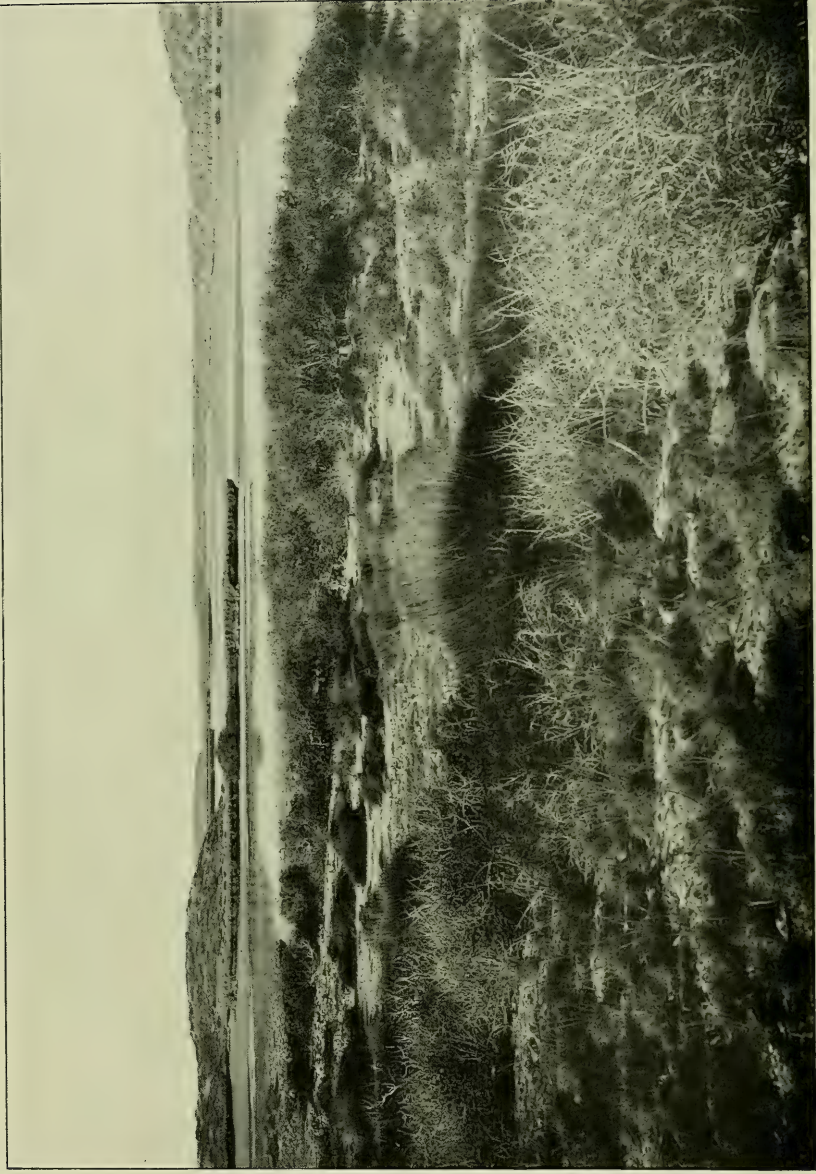




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- NEST & YOUNG OF HALIAETUS LEUCOGASTER.





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HOME LAGOON & VEGETATION OF HERMITE ISLAND.

35. A Report on the Fauna of the Monte Bello Islands.  
By P. D. MONTAGUE, B.A., Gonville and Caius College,  
Cambridge\*.

[Received March 18, 1914; Read June 9, 1914.]

(Plates I.-IV.†)

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Off the coast of Western Australia, from the North-West Cape to Port Walcott, there stretches an archipelago of small desert islands, the zoology of which has been but little investigated. Lying as they do, in a shallow sandy sea, and for the most part in sight of the low shores and mangrove-swamps of the mainland, it is unlikely that their fauna should exhibit any marked insular characters, but they offer great opportunities of considering the typical forms which inhabit them in relation to their somewhat peculiar environmental conditions. Of all these islands the Monte Bello Group is the most isolated, and so from its position the most likely to repay investigation.

Mr. T. H. Haynes, a gentleman engaged in experimenting upon the artificial cultivation of Pearl Oysters, was for some time living upon these islands, and in his leisure collected various zoological specimens, which he sent to the British and West Australian Museums. His house was subsequently wrecked by a cyclone, and he was obliged to abandon his investigations. Since many of Mr. Haynes' specimens presented features of interest, Mr. Bernard Woodward, Director of the West Australian Museum, thought it desirable that the group should be thoroughly investigated, and a grant was offered for the purpose. As this was insufficient a special application was made to the Royal Society, resulting in a further grant of £50. These grants

\* Communicated by Prof. J. STANLEY GARDINER, M.A., F.R.S., F.Z.S.

† For explanation of the Plates see p. 652.

enabled the writer, accompanied by Mr. L. Burns, of Perth, W.A., as assistant, to spend from May 29th to August 29th, 1912, collecting upon the islands. Mr. Burns has since been drowned while duck-shooting at the Forrest River, near Wyndham. He was a very able collector and a delightful companion.

I must here acknowledge the very great assistance received from Professor Stanley Gardiner at home, from Mr. Woodward and Mr. W. B. Alexander in Western Australia, and from Mr. Gregory Mathews and workers in various departments of the British Museum (Natural History), who have so kindly helped in identifying the specimens.

A detailed description of a local fauna is incomplete without some account of its environment; it is therefore necessary to consider the prevailing physical conditions and geographical features of the locality before proceeding to an account of the various forms inhabiting it.

The group lies approximately in lat.  $20^{\circ} 25' S.$ , long.  $115^{\circ} 30' E.$ , 105 miles E.N.E. of North-West Cape, and 40 miles from the mouth of the Fortescue River—the nearest point on the mainland. It is near this latitude that the rainfall on the West Australian coastal region reaches its minimum, averaging under 8 inches per annum; it is of very irregular occurrence, droughts of two or even three consecutive years being not infrequent. The rain falls in the summer, usually in January or February, and is frequently attended by a particularly severe form of cyclone known locally as a “Willi-willi.” These storms strike the West Australian coast between latitudes  $18^{\circ}$  and  $23^{\circ}$ , and cause much destruction to buildings and shipping. Their wind velocity has never been accurately measured, but lines of short iron telegraph-poles bent in the middle through as much as  $45^{\circ}$  testify to the force attained. Cyclones may occur between November and March; from mid-April until October, comparatively calm and dry weather may be depended upon. During these months there are occasional winter showers, which become more frequent and regular further from the coast. Hence the islands are favoured with a slightly higher rainfall, and the vegetation is in consequence a little more luxuriant and less scattered than that of the mainland in the corresponding latitude. Though these showers are refreshing when they do occur, they are really very scanty, and contribute but little to the average, for the bulk of the rain falls in one or more tropical downpours during the course of a few hours.

The temperature is not excessive; during our visit the shade temperature at mid-day averaged  $82.3^{\circ}$ , never rising above  $90.0^{\circ} F.$

The geological formation throughout is of sandy post-tertiary limestone, similar to that of the mainland, which extends in an interrupted belt down the greater length of the west coast of the continent, and is supposed to have accumulated by wind-action.

The Monte Bello rock is comparatively poor in Foraminifera, but contains numerous fragments of broken shell. Most of the lime is concentrated near the surface, and the bare hill-tops on Hermite Island are covered in places with an extremely dense and hard marble-like surface deposit, only a few inches in thickness, formed by rapid surface-evaporation drawing up the water from the lower levels and depositing its mineral contents.

The main geographical features of the group are indicated on any map. It lies at the northern extremity of an extensive shoal, which stretches in a southerly direction to within fifteen miles of the mouth of the Robe River, including Barrow, a comparatively large island lying twelve miles S. by S.W. of the Monte Bello Group. The southern portion of this shallow area, known as Barrow Island Shoals, has soundings of  $2\frac{1}{2}$  fathoms, and dries in patches at low water. This closely approaches another bank, which lies between the mouths of the Cane and Robe rivers, including the Mary Anne Islands. The passage between these shoals is only four miles wide, and nowhere more than nine fathoms in depth. Half encircling the Monte Bello Group on the north and west sides is Breakin's Reef, which is the actual limit of the bank. It is not a coral formation, although there are plenty of corals upon it, and it dries in patches at low water with the spring tides. Outside the 'reef' soundings of 40-50 fathoms are struck almost immediately. It seems likely that this shallow area at one time formed an extensive triangular cape, of which the Monte Bello Islands formed the northern extremity, having become separated at a comparatively recent period. Barrow Island was probably connected with the Monte Bello Islands long after its separation from the mainland, a supposition supported by zoological evidence hereafter to be dealt with.

It will be well now to describe the respective characters of the two main islands, Hermite and Trimouille.

Hermite Island, the largest and most fertile, measures rather over six miles from N. to S., and about one and three-quarters across at its widest part. The coast-line is irregular, and extensive shallow inlets run far inland amongst low undulating hills, nearly dividing the island longitudinally into an Eastern and a Western portion. The coasts facing the open sea are rocky and irregular, with low rugged cliffs and stony beaches; but the shores of the inlets are regular and characteristic, the hills sloping down to a flat rocky terrace, which is bare of vegetation and washed by the sea at very high tides in windy weather. This terrace descends nearly perpendicularly to the regular tidal flat, and its edge is much undercut, owing to the tides which flow swiftly up and down the long and narrow inlets, and to the absence of big seas, which would break up the configuration. Since these inlets are locally called 'lagoons,' I shall continue to speak of them as such, though they have nothing to do with the true lagoons associated with coral formations. In the sheltered

bays and inlets, there are growths of 'mangrove' comprising an *Avicennia*, which grows to a considerable size and forms a belt of varying width skirting the sandy flats just below high-water mark. Further out in the lagoon, the *Avicennia* gives place suddenly to a true mangrove of the genus *Bruguiera*, which forms another zone, and at the head of the large lagoon extends right across to the *Avicennia* belt along the opposite shore.

The highest point on the island is 180 feet above sea-level. Though the hills and ridges are low, their slopes are steep, with much bare and weathered rock showing between the scanty vegetation. The level plains are covered with a light, sandy, red soil, very fertile when sufficiently watered. The vegetation is of a type known collectively as '*Spinifex*-scrub,' which covers large tracts of north-western Australia. *Spinifex* is the predominant plant over most areas; it grows in dense prickly tufts and patches, in some places the shrubs so close together that walking amongst them is a tortuous and somewhat painful business. Next in abundance to the *Spinifex* is *Myoporum acuminatum*, a shrub with bright green foliage and small white flowers, very attractive to *Lycænid* butterflies. An *Olearia* is also common; it is a tall and wiry shrub, with insignificant flowers, and small and rather scanty linear leaves, giving little cover. The branches generally bear the large cobwebs of a big and handsome spider, *Nephyla meridionalis*. Of the less abundant shrubs must be mentioned a *Cassia*, apparently near *C. oligrelada*, and a species of *Croton* (Euphorbiaceæ), a coarse, rough bush, generally affecting the upper slopes of the ridges. Characteristic of the areas along the shores may be mentioned a Chenopodiaceous plant, *Rhagodia billardieri* R. Br., forming a bush of moderate proportions with clusters of inconspicuous green flowers, attractive to insects. The almost universally distributed *Salsola kali*, Linn., occurs abundantly, and *Frankenia pauciflora* grows commonly on the limestone rocks, around the sheltered lagoons being seen in isolated patches almost down to the water's edge. Of the more abundant herbaceous plants may be mentioned *Tricholesma zeylanicum* R. Br., which usually stands alone or in loose clusters on bare patches of soil, its bright blue flowers very conspicuous. A species of *Senecio* is also rather common, remarkable in that it usually forces its way up through dense patches of *Spinifex*.

This brief account of the characteristic vegetation applies only after a period of drought, such as there had been previous to our visit to the islands. A good shower had fallen in April 1912, but it was in all probability insufficient to bring up the majority of the herbaceous annuals, which are short-lived, and flourish only for a month or two after the heavy tropical rains. At such times the island may present a different aspect.

There is no surface-water on Hermite—or in fact, on any of the islands—during the dry season; our water-supply was derived from a well, which had been sunk for fifteen feet through the porous rock, and which yielded us a permanent though scanty

supply. After the rains, water may be obtained from surface-diggings in the sand-hills situated to the west side of the island.

Trimouille in many respects differs markedly from Hermite Island. The coast-line is far more regular, and there is but one inlet. This is quite unlike the lagoons of Hermite, for there are no rocky margins, and the dunes rise directly from shores of white sand. It forms, in fact, a more or less circular bay, with a narrow entrance. From the south side there runs off a tidal creek, around which there is a considerable growth of mangrove, but the *Avicennia* and *Bruguiera* are intermixed, and do not form separate zones. The vegetation here is also peculiar, consisting almost entirely of Chenopodiaceous plants comprising both shrubs and herbs, mostly of the genus *Atriplex*, *A. isatidea* Moq. covering large areas of the sandy foreshore.

This particular spot is the chief haunt of a small bird, *Zonæginthus castanotis roebucki*, which though widely distributed on the mainland, is in the Monte Bello Group confined to Trimouille, though individuals occasionally cross over to South-East Island, which lies off its south-eastern end. (See p. 636.)

Nearly the whole of Trimouille is covered with blown sand, which towards the north-western end has collected into dunes of considerable size, two of which are particularly prominent, the largest rising to a height of 120 feet. At the foot of this hill, fresh water can be permanently obtained by shallow digging. The sand at the south-eastern extremity of the island is very coarse in texture, almost gravel, becoming gradually finer towards the north-western end. This sifting effect, due to the wind, was possibly of only a temporary nature, the result of a recent gale.

As might be anticipated, the vegetation is far less luxuriant and more scattered than on Hermite Island, though it is quite as varied. *Spinifex* is much in evidence, and on the sand-hills facing the sea one frequently meets with the widely-distributed *Ipomœa pes-capræ*, growing in a form with immensely long trailing stems, with erect tufts of glossy green leaves and pink flowers, separated by internodes as much as 20 feet in length. *Tribulus cistoides* Linn., *Boerhaavia diffusa* Linn., and *B. repanda* are all common, the latter often trailing up over the shrubs like a regular climber, though it grows equally well alone.

Of the smaller islands little need be said, for they embody to a greater or lesser extent characteristics already described. There is quite a varied flora on some of the smallest outlying islets, for the soil has an extra fertility imparted to it by the 'mutton-birds,' which breed in large numbers in burrows in the sand and holes in the rocks.

In the following survey of the animals represented, stress has been laid upon small differences which may indicate zoological isolation, and trinomials have been adopted wherever it was thought desirable, but only where the series show uniformity.

Owing to the general scarcity of life, in consequence of the arid conditions prevailing, it was often not possible to get a really sufficient number of specimens. Particularly in the case of insects, the matter is complicated by the fact that, where there is no great abundance of individuals, any collected at the same time and place are liable to be of the same brood. Thus all may exhibit a slight peculiarity, and give a false impression of uniformity in a character which may really be quite exceptional.

## MAMMALIA.

There are now two indigenous animals inhabiting these islands, a Hare Wallaby, *Lagorchestes conspicillatus* (Gould)\*, and a Bat, *Eptesicus pumilus* Gray. There was formerly a Bandicoot, *Isodon barrowensis* Thom., which until very recently inhabited Hermite Island, but has now been exterminated.

Of introduced species, cats and black rats (*M. rattus rattus*) are numerous, and, as in other places, doing great damage to the endemic fauna. The brown rat (*M. decumanus*) has already established itself in a store-shed used by one of the pearling fleets, but it does not appear to be thriving, for all the examples observed were in a weak and diseased condition.

### 1. LAGORCHESTES CONSPICILLATUS (Gould).

This species is closely allied to the more slender and agile rufous-coloured "subspecies" *L. c. leichardti*, which is widely distributed over tropical Australia. It is now confined to Hermite and Barrow Islands, and Mr. Oldfield Thomas, who has kindly identified the species, can detect no difference between examples from the two localities. There is a specimen in the British Museum, a co-type from the Gould collection, which is recorded as having been obtained from "Trimouille I., Dampier Archipelago." It is more than likely that this is a Monte Bello example, for there is no island of that name in the Dampier Archipelago, and on some of the older charts the Monte Bello Group is represented by a single island named Trimouille. Whether it actually came from Trimouille, and not from Hermite Island, it is impossible to decide, but at the present time the species lives only on the latter, though old pearl-ers say that it was formerly abundant on the former. The majority of known specimens are from Barrow Island, where the species still occurs; I am aware of no other locality.

In habits it is nocturnal, hiding by day amongst the thick *Spinifex*-tufts, and coming out just after sunset to feed upon the bark and young shoots and foliage of various herbs and bushes. It is unlikely that it will exist for many years longer, as

\* The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature (Proc. 7th Int. Cong. Boston, 1907, p. 44 (1912)).—EDITOR.

it is one of the most defenceless animals that can well be imagined. It is easily dislodged from its hiding-place amongst the *Spinifex*, from which it often rises in an awkward fashion, tripping up and rolling over before getting away. Though it is able to hop swiftly for a short distance, it rapidly becomes exhausted, and is not difficult to obtain by simply running after it and catching it by the tail.

The breeding-season appears to be during the summer and is possibly dependent upon the rains, for we saw no half-grown specimens, and as the rains of the previous summer had failed, they may not have bred at all. It is possible, however, that the cats had accounted for all the young ones. The pouches of all the females were empty, but in the middle of August males and females were often seen in pairs.

The species under consideration offers a very striking example of "degeneration" resulting from isolation and consequent absence of enemies. Owing to the lack of surface-water upon these islands, it has never had to face the dingo and the aborigines, who would make short work of an animal so easily caught. It is remarkable that it has been able to brave the climatic conditions for so long, and has not succumbed to a particularly severe drought or cyclone. The identity of this species with that of Barrow Island indicates a comparatively recent land-connection, but from all the other smaller islands, which presumably formed part of the same land-mass, the species has disappeared.

## 2. ISOODON BARROWENSIS Thom.

Only shrivelled skins and bones of this species were discovered, but skulls correspond in all essentials with specimens from Barrow Island, with which it is in all probability identical. The cats have evidently been responsible for its extermination. Its distribution corresponds exactly with that of the species last described, and here again it is quite distinct from the corresponding mainland form.

## 3. EPTESICUS PUMILUS Gray.

This little bat occurs on the North-West Australian mainland, and is not uncommon over the whole Monte Bello Group, appearing upon the wing about sunset. It was generally observed near rocks and cliffs, where it probably spends the day.

*Introduced species.*—It is curious to find *Mus rattus* particularly common on the small outlying islands of the group which have never been inhabited, frequenting the beaches and sand-hills near the coast. It occurs on practically every island, and its presence is attributed to a pearling-schooner which was wrecked some twenty years ago. All the specimens we obtained were

well-grown examples of typical *M. rattus*, with long black fur and dark grey underparts—not the brown, light-bellied var. *alexandrinus* which is more usually found in such situations. They appeared to feed upon small crabs on the shores between the tide-marks, and to derive their water-supply from gnawing the stems and leaves of succulent plants. Their tracks were very noticeable on the sand-hills, in some places forming well-worn paths, which usually led to holes in the rocks, where they breed.

The cats which have been introduced into Hermite Island appear to be breeding rapidly; wherever introduced they soon become exceedingly shy and wary, and grow to a very large size. They will, no doubt, in a few years time have accounted for the wallabies, as they have for the bandicoots. If they cannot kill a full-grown wallaby—though I am inclined to believe they do—they make short work amongst the young ones.

## AVES.

In the following notes, the nomenclature adopted is that of Mr. Gregory Mathews, to whom I am greatly indebted for his very kind assistance in identification. The numbers after the names given in the notes on the different species refer to Mathews' "Reference List of the Birds of Australia," 1912.

### LAND BIRDS.

1. *GEOPELIA HUMERALIS HEADLANDI*. 50 B. Pale Barred-shouldered Dove.

Compared with the type, these birds agree in all necessary detail. The species frequents the more bushy parts of the islands, feeding upon fallen berries and seeds. They roost and nest in the mangroves, constructing a loose platform of sticks amongst the branches, upon which two white eggs are laid. The nesting-season is dependent upon the rains, occurring usually in January or February, but after a shower of rain on July 8th, 1912, the males at once began to show signs of courtship, and by the end of the month a small percentage of the birds were breeding.

Individuals were nearly always to be seen around the well and an abandoned water-tank containing brackish water, into which they used to fly to drink and bathe. The problem at once suggests itself as to how they fared before these tanks were built. The dews are usually heavy, and the smaller birds were sometimes observed drinking the dew-drops from the bushes in the early morning, but, when the easterly winds are blowing, this source fails entirely for days in succession. The only other species which frequented artificial water-supplies is the little "finch," *Zonæginthus castanotis roebucki*, which visited the "well" on Trimouille in flocks. Although at the time of our arrival the well was choked, and several inches of material had

to be removed before any water collected at all, yet the damp sand was pitted and scored all over the surface by the beaks of birds.

The distribution of this dove ranges from about Sharks Bay to the mouth of the Shaw River.

♂: wing 137 mm.; culmen 18; tarsus 21.5.

♀ " 125-7 mm.; " 17; " 20.

Iris orange-red; bill dark slate-colour; feet salmon-pink, claws black.

2. *HALCYON SANCTUS WESTRALASIANUS*. 557. Western Sacred Kingfisher.

*Halcyon westralasianus* Campbell, Emu, vol. i. p. 25, 1901.

One specimen, not fully adult, agrees with specimens from S.W. Australia rather than with *H. s. ramsayi* Mathews, from the N.W. of the continent. The specimen was shot in its haunts among the mangroves, where it did not seem to be at all common.

♀ (immature): wing 90 mm.; culmen 36; tarsus 12.

Iris brown; bill slaty black, pale at base of lower mandible; feet brown, claws black.

3. *HALCYON SORDIDUS MELVILLENSIS*. 560 A. Northern Mangrove Kingfisher.

Mathews, Austral Avian Record, vol. i. p. 38, 1912.

Two immature examples agree in size and general appearance with birds from Melville Island. The specimens were obtained amongst the thick mangroves of Hermite.

♀ (immature): wing 97 mm.; culmen 49; tarsus 13.

Iris brown; bill slaty black, pale at base of lower mandible; feet brown, claws black.

4. *CHRYSOCOCCYX BASALIS WYNDHAMI*. 586. Western Narrow-billed Bronze Cuckoo.

Five examples of this bird, from the unbarred immature form to the fully adult, agree with the western bird described by Mathews. The species was found only upon Hermite, where it is not uncommon, especially in the dense mangrove-forest at the head of the Large Lagoon. It is a shy bird, but usually betrays its presence by its shrill note—a clear whistle several times repeated.

♂ (adult): wing 104 mm.; culmen 12; tarsus 18.

♀ (adult): " 97 mm.; " 12; " 17.

Iris dull orange-red; culmen dark brown; feet brown.

Young: iris grey.

5. *PACHYCEPHALA RUFIVENTRIS COLLETTI*. 698 A. Northern Thickhead.

Mathews, Austral Avian Record, vol. i. p. 41, 1912; Parry's Creek, North-West Australia.

An immature male resembles the north-western bird described by Mathews as above.

The specimen was shot late in June. It was in company with several others of the same species, but, before or after that date, no others were seen. It is probably a casual visitor to the islands.

♂ (immature): wing 91 mm.; culmen 13; tarsus 20.

Iris brown; culmen light brown, dark at tip; feet dark brown.

6. *EPHIANURA TRICOLOR DISTINCTA*. 845. Northern Tricoloured Chat.

One male example has a much darker back than the type of the above bird; darker, indeed, than any specimens examined, but the species is variable in this respect.

The species occurs very sparingly upon Hermite; only two examples were observed, frequenting the thick bushy localities on the east of the island.

♂: wing 69 mm.; culmen 13.5; tarsus 19.5.

Iris brown; culmen dark brown; feet dark brown.

7. *EREMIOENIS CARTERI ASSIMILIS*. Island Desert Bird.

Montague, Austral Avian Record, vol. i. p. 181, 1913.

Differs from *E. c. carteri* in its smaller size, proportionately larger bill, and in the colour of the head, which is of a deeper and richer chestnut-brown.

The mainland representative (*E. c. carteri*) is a somewhat scarce bird inhabiting the *Spinifex*-country in the region of North-West Cape. The Monte Bello form is found principally upon the *Spinifex*-plains of Hermite, where it is rather common. It frequents the low scrub, slipping with ease and rapidity amongst the very thickest and most prickly bush, making good use of its long tail to guide and balance itself in so doing. Occasionally it will appear for an instant at the summit of a bush or tuft, utter a harsh clucking note, and disappear almost immediately, or make a short and hurried flight to the next thicket.

♂: wing 60 mm.; culmen 12; tarsus 19.5.

♀: „ 51 mm.; „ 12; „ 14.

Iris brown; culmen dark brown; tarsus brown.

8. *ARTAMUS LEUCORHYNCHUS HARTERTII*. 992. Western White-rumped Wood-Swallow.

This bird belongs to the West Australian form described by Mathews. It was met with commonly upon all the islands, usually to be seen hawking insects upon the wing, or, towards the middle of the day, resting upright upon bare twigs or stumps, in parties of three or four to a dozen. It would often accompany us while walking over the plains, and catch insects as they were dislodged from the *Spinifex*.

9. *ZOSTEROPS LUTEA BALSTONI*. 1099. Carnarvon White-eye.

*Zosterops balstoni* Grant, Ibis, 1909, p. 663.

Specimens agree with the type of the above bird from Carnarvon, North-West Australia. The species is a small, dull-coloured form of *Zosterops lutea* Gould, though it would be more correct to look upon the type *lutea* as an island form of the far more widely distributed *balstoni*. It is much the most numerous bird inhabiting the Monte Bello Group, living upon all the islands, however small, where there is sufficient scrub to afford food and protection. It appears to be omnivorous in diet, feeding upon berries and seeds, and searching for insects amongst the foliage of the mangroves, in the vicinity of which it is always to be seen.

The nesting season is probably in October. In August, the males were in full song, and at the end of that month a half-constructed nest was discovered, suspended amongst the foliage of a dense *Bruguiera*, but it was not completed when I left.

♂: wing 57 mm.; culmen 9.5; tarsus 17.

♀: „ 56 mm.; „ 9.0; „ 17.

Iris brown; bill black; feet dark brown.

10. *STIGMATOPS INDISTINCTA PERPLEXA*. 1201. Allied Least Honey-eater.

The specimens agree with birds from mid-Westralia. On the Monte Bello Islands the species was met with exclusively in the larger mangrove-forests of Hermite, frequenting the densest parts of the *Bruguiera*-zone. During July and August the males were in full song. The song is particularly pleasing, somewhat suggestive of that of the European Reed-Warbler, but more musical and less harsh. When singing amongst the dense and tangled vegetation the bird is extremely difficult to locate.

♂: wing 69 mm.; culmen 14.5; tarsus 20.

♀: „ 65 mm.; „ 14.0; „ 18.

Iris greyish brown; bill blackish brown; feet dark brown.

11. *ANTHUS AUSTRALIS MONTEBELLI*. Montebello Pipit.

Montague, Austral Avian Record, vol. i. p. 181, 1913.

This is a pale subspecies, in which the dark centres of all the feathers are much reduced, and the spotting on the breast is comparatively sparse. It lacks any rufous tinge.

This is a common bird over the whole group, being perhaps especially abundant upon Trimouille. It is the only species of land-birds which was observed to fly from island to island over passages more than two hundred yards across. It was met with everywhere on the open country, both on the rocky hillslopes and on the sandy plains.

♂: wing 89 mm.; culmen 12; tarsus 24.

♀: „ 85 mm.; „ 12; „ 23.

Iris brown; bill black; feet light brown.

12. *ZONÆGINTHUS CASTANOTIS* ROEBUCKI. 1347. Dark Chestnut-eared Finch.

This bird resembles the form from Roebuck Bay in being dark above, and in having the dark ear-patch. The species in its various forms is widely distributed over the Australian continent. On the Monte Bello Group it is confined to Trimouille and South-East Island. Its head-quarters is the lagoon towards the north-west end of the island, which has already been described. Large, loose spherical nests, composed of dry herbaceous stems and lined with feathers and soft grass, were often to be met with amongst the branches of *Avicennia*, and one was found amongst the rocks under an overhanging cliff-edge. They contained no eggs; the breeding-season probably commences in October.

♂: wing 59 mm.; culmen 10; tarsus 14.

♀: „ 56 mm.; „ 9·5; „ 13·5.

Iris orange-red; bill orange; feet flesh-colour.

Land-birds alone are likely to furnish indications of zoological isolation and pre-existing land-connections. It will be seen that, with one exception, the above list only comprises birds which inhabit the North-West of Western Australia. The exception is *Halcyon sanctus westralasianus*, the subspecies inhabiting the South-Western region. The fact is of interest, as one would naturally have expected to find *H. s. ramsayi*, the North-Western bird, and the occurrence of South-Western forms on the Monte Bello Group is found also in the invertebrate fauna. Of the peculiar forms, *Eremiornis carteri assimilis* might have been anticipated, as it is a bird addicted to one locality and apparently incapable of prolonged flight. It has not been reported from Barrow Island, however, where there occurs in its stead a blue *Malurus*, which is absent from the Monte Bello Group. It is curious, on the other hand, that a bird so widely distributed and strong on the wing as *Anthus australis* should be also represented by a readily distinguished subspecies, whereas the *Zosterops*, a no less characteristic and abundant bird, of a genus quite remarkable for its insular forms, should be identical in every respect with the type from Carnarvon.

#### SEA-BIRDS, WADERS, AND BIRDS OF PREY.

13. *HYDROPROGNE TSCHEGRAVA STRENUA*. 128. Caspian Tern.

*Sylochelidon strenuus* Gould, Proc. Zool. Soc. Lond., 1846.

This bird is distributed around the coasts of South and Western Australia, and was found in scattered pairs frequenting the low flat islets at the north of the group. A single half-grown young one was discovered among the rocks on a beach of Trimouille, at the end of July.

## 14. BRUCHIGAVIA NOVE-HOLLANDIÆ LONGIROSTRIS. Silver Gull.

*B. longirostris* Masters, Proc. Linn. Soc. N.S.W., vol. ii. p. 113, 1877.

The range of the form extends from S.W. to N.W. Australia. Around the Monte Bello Islands it is not abundant; the whole of the north-western region is, in fact, remarkable for the comparative scarcity of sea-birds, in spite of the existence of extensive flats and shallows which ought to furnish an abundant food-supply.

A few old nests, apparently of this species, were found upon Long Island and several of the outlying rocks, and the breeding-season is said by the pearlers to be in December and January. The nesting-time of the gulls varies enormously and individually upon the various island groups around the West Australian coast, occurring, it would appear, any time between October and April.

## 15. HÆMATOPUS LONGIROSTRIS.

Fairly numerous around the sandy shores and mud-flats, feeding in small parties, often in company with the next species.

## 16. HÆMATOPUS UNICOLOR OPHTHALMICUS.

The Montebello Sooty Oystercatcher is the bird described as above, distinguished from *H. u. bernieri* by the bare orange-red space around the eyes. It is really a North Australian bird, and the Monte Bello Islands must be near the southern limit of its range, *H. u. bernieri* being the typical West Australian form.

## 17. EUPODA GEOFFROYI. 201. Large Sand Dottrel.

*Charadrius geoffroyi* Wagler, Syst. Av., Charadr. sp. 19, 1827; Java.

The distribution is from Southern Siberia southwards to Australia, where it occurs during summer, and in the northern part of which it has often been taken in full breeding plumage.

Observed in small numbers, usually feeding in company with *E. mongolus* and *C. ruficapillus* on the tidal flats of Hermite, throughout June, July, and August. The specimen obtained was shot on July 9th.

♂: wing 133 mm.; culmen 23; tarsus 33.

Bill dark brown; iris brown; feet dark brown, claws black.

## 18. EUPODA MONGOLUS. 202. Mongolian Sand Dottrel.

*Charadrius mongolus* Pallas, Reise Russ. Reichs, vol. iii. p. 700, 1776; Mongolia.

The same remarks apply as to the former species.

♀: wing 129 mm.; culmen 17.5; tarsus 30.

## 19. CHARADRIUS RUFICAPILLUS TORMENTI Mathews. 205. Pale Red-capped Dottrel.

Specimens agree with the above pale subspecies described by

Mathews; it is distinct from the eastern bird. It is distributed all along the coasts of Mid- and Western Australia and the Northern Territory.

Observed throughout June, July, and August; being seen generally on the tidal flats at low water, but flying about in flocks when the tide is high along the outer shores. Specimens were shot on June 10th and July 4th.

♂: wing 102–105 mm.; culmen 13·5; tarsus 25.

20. *PISOBIA MINUTA RUFICOLLIS*. 230. Little Stint.

*Trynga ruficollis*, Pallas, Reise Russ. Reichs, vol. iii. p. 700, 1776; Siberia.

The same remarks apply as to *Eupoda geoffroyi* and *mongolus*. Specimens obtained on July 10th.

♂: wing 109 mm.; culmen 17·5; tarsus 17·5.

♀: „ 101 mm.; „ 16; „ 18.

21. *DEMIEGRETTA SACRA*. Reef Heron.

This species was observed commonly, and both white and grey forms were seen, though only the latter, which is by far the most plentiful, was obtained. They were generally to be found about the rocks and cliffs of the outer shores, seldom frequenting the more sheltered inlets. A nest, containing three eggs, was discovered on a small flat islet to the north of Hermite. It formed a lining of loose sticks to a depression in the rock, a few feet above high-tide level. Only a yard or two away there was an Osprey's nest with newly-hatched chicks; although this bird will not tolerate another nest of its own species upon the same island, it does not in the least resent the presence of that of a different bird.

22. *PELECANUS CONSPICILLATUS*. New Holland Pelican.

Observed in small parties, usually of a dozen or so, around the islands to the north of the group. They do not breed in the vicinity.

23. *HALIAETUS LEUCOGASTER* Cuv. White-bellied Sea-Eagle. (Pl. III.)

This species, which enjoys a wide distribution, from the coasts of India, Ceylon, Malay Archipelago, and Australia to Western Polynesia and Tonga, occurs abundantly on the islands off North-Western Australia. Two pairs were nesting upon the Monte Bello Group, one at the extreme south-eastern end of Trimouille, and another on a small flat islet to the north of Hermite. The former nest was placed upon a sloping ledge of a cliff, and a great quantity of material was employed to bring the outer edge to the level of the inner portion; it was consequently a bulky structure, 5 ft. 6 in. in diameter—composed of sticks and seaweed, with no obvious cavity or lining—forming a safe and level platform for the single chick. In the second instance, there was practically

no nest, the single newly-hatched chick lying in a depression in the flat rock, into which had been placed a scanty collection of grass and sticks as a lining; here there was no danger of the egg or young bird falling out and being destroyed.

The species seems to subsist entirely upon fish and sea-snakes, never molesting the sea-birds (at least the adults), though the pair upon Trimouille were subject to violent attacks from a pair of Ospreys which were nesting upon a neighbouring rock. Whenever they were in the air together, the Ospreys would circle above the Eagle, screaming loudly, and then suddenly swoop down upon it. The latter bird would usually turn sharply sideways or almost upon its back, holding out its formidable talons and thus warning off its assailants, a feat of balance and flight fascinating to watch.

#### 24. HALIASTUR GIRRENERA Vieill.

This species occurs around the coasts of Northern and Eastern Australia, and New Guinea. The N.W. Cape and Monte Bello Islands are near the southern limit of its distribution on the west side of the continent. In the region of the Ashburton River it is not uncommon, and two pairs were observed upon the Monte Bello Islands, where they seem to subsist almost entirely upon small rock-crabs. On Trimouille one of these birds was observed to leave a heap of broken limbs and empty carapaces, which formed a pile more than a yard across upon a slab of rock in a large shallow cave to the east of the island. A nest containing similar remains was discovered amongst the mangroves on Hermite. It was placed in the fork of a *Bruguiera*, and was deep in form, about equal in size to that of a crow and composed of sticks, seaweed and *Spinifex*, with no distinct lining. It contained a single egg, dirty white in ground-colour, with scanty and minute streaks and sparks of rusty brown.

#### 25. PANDION HALIAETUS MELVILLENSIS. 373. Northern White-headed Osprey. (Pl. II.)

Mathews, Austral Avian Record, vol. i. p. 34, 1912; Melville I.

This Western Australian form of the almost cosmopolitan species occurs very abundantly, particularly frequenting the archipelago of flat rocks and islets lying to the north of the group, upon nearly every one of which there was a nest. The majority had laid early in June, but fresh eggs were obtained late in July and early in August. The nest is a conspicuous and bulky structure, ranging from about 11 inches to 5 feet in height, but always measuring about 3 ft. 6 in. in internal and about 5 feet in external diameter. It is composed of sticks, drift-wood, seaweed and bits of coral, etc., the shallow cavity being lined with finer seaweeds and any other soft material. Only one nest is ever found upon an island, though nests may be in close proximity if separated by water. When situated upon a low rock, the nest is usually four to five feet high and forms a conspicuous object. On the larger islands it is

generally a smaller structure, placed in some elevated position such as the top of a steep hill or a cliff overlooking the sea.

The eggs in nearly every case were three in number, one of which was often addled, creamy white in ground-colour, boldly blotched with deep reddish brown and underlying markings of purple-grey. Average measurements,  $60 \times 47$  mm. The young when hatched are covered with grey down, and in their first plumage the head and breast are much streaked with brown.

The food, judging from remains found in the nest, consists mostly of sea-snakes and a sphyrænid fish, known locally as 'Pike,' which swims near the surface over the sandy shallows. In catching prey so slippery and narrow in girth, the conical and sharply pointed enlarged scales under the feet must be of especial service. As has often been observed in other localities, the prey is always carried lengthwise.

## REPTILIA.

The following is a list of the Reptiles inhabiting the group. The nomenclature adopted is that of Boulenger, Brit. Mus. Cat. of Lizards, 1885, and Cat. of Snakes, 1893. I have to thank Mr. Boulenger for his kind assistance in identification.

### 1. HETERONOTA BINOEI Gray. (Pl. I. figs. 1-3.)

Gray, Cat. p. 159; Boulenger, B.M. Cat. vol. i. p. 151.

This species is distributed over Western Australia and the islands off the coast. On the Monte Bello Group it is very abundant, and the individuals are of large size and extremely variable in colour. It is nocturnal in habit, hiding by day under stones or pieces of wood, but at night it may be seen in numbers with the aid of a lantern, moving about rather sluggishly over the sand in search of the small beetles and spiders upon which it feeds.

### 2. GEHYRA VARIEGATA, B.M. Cat. vol. i. p. 151.

*Peripia variegata* Gray, Cat. p. 159.

This little gecko is widely distributed over Australia and Polynesia, though most of the records are from the north and west of the continent. On the Monte Bello Islands, it occurs quite commonly on the sandy plains which are well clothed with scrub, hiding by day in the sand, and ascending the bushes at night in search of insects. Nearly all the examples were obtained at night upon stumps and posts which had been 'sugared' for moths, preying upon the insects as they alighted.

The specimens obtained, which are all from Hermite, are of small size, and show in every case four longitudinal rows of light spots down the dorsal surface, which are absent from the majority of examples examined from other localities. It is remarkable

that on Hermite this species and *H. binoei* bear a strong superficial resemblance to one another, both in size and coloration. The resemblance in size is perhaps the most remarkable, as the following figures will show:—

*H. binoei*: length, B.M. Catalogue, 80 mm.; Hermite specimens, 103 mm.

*G. variegata*: length, B.M. Catalogue, 147 mm.; Hermite specimens, 87 mm.

The discrepancy between the Monte Bello forms is largely accounted for by the long slender tail of *H. binoei*, the average measurements of the largest specimens from snout to base of tail being in the two cases, *H. binoei* 58·4 mm. and *G. variegata* 54 mm. Furthermore, it may be observed that the white spots on *G. variegata* correspond to some extent in position and appearance to the white tetrahedral scales on the back of *H. binoei*. The fact is interesting, as the two species are found together on the same ground, though the one obtains its food on the sand and the other on the bushes above.

### 3. PHYSIGNATHUS GILBERTI. (Pl. I. figs. 4–7.)

B. M. Cat. vol. i. p. 396.

*Lophognathus gilberti* Gray, Cat. p. 12.

This large and handsome lizard was seen very abundantly on Hermite Island, and occurs on nearly all the other islands. On warm and sunny days it could be seen almost anywhere, running and jumping with great agility over the rocks and trees, feeding mostly upon a large and abundant grasshopper, *Cyrtacanthacris guttulosa*.

The species is distributed over Northern and Western Australia. Montebello examples are greatly below the average size.

### 4. ABLEPHARUS MUELLERI, B. M. Cat. vol. iii. p. 356.

*Phaneropsis muelleri* Fisch., Arch. f. Nat. 1881, p. 236, pl. xii.

This lizard is probably common, for the regular waved track, formed by its burrowing through the surface sand, was frequently seen in the early morning, an indication that the species is nocturnal in its movements. Owing to the great rapidity with which it burrows, it is hard to capture, and our examples were obtained by turning over loose rocks in large numbers. It had previously been recorded only from Western Australia.

### 5. LYGOSOMA BIPES, B. M. Cat. vol. iii. p. 337.

*Rhodona bipes* Fisch., Arch. f. Nat. 1882, p. 292, pl. xvii. figs. 10–15.

Apparently resembles in habit the preceding species, and obtained from the same locality in the same manner. It is apparently confined to N.W. Australia.

6. *LYGOSOMA LESUEURII*, B. M. Cat. vol. iii. p. 225.*Hinula australis* Gray, Cat. p. 77.*Tiliqua australis* Gray, Ann. Nat. Hist. ii. 1838, p. 291.

This species is fairly abundant on all the larger islands, frequenting generally the limestone slopes of the hills, and during the heat of the day running about with great activity. Distributed over Western Australia.

7. *LYGOSOMA ISOLEPIS*, B. M. Cat. vol. iii. p. 234, pl. xv. fig. 1.*Hinula tenuis* Gray, Cat. p. 76.

Rather common on the *Spinifex*-plains of Hermite. Diurnal, feeding upon flies and the smaller Orthoptera. Distributed over Western Australia.

8. *VARANUS GOULDII*, B. M. Cat. vol. ii. p. 320.*Monitor gouldii* Gray, Cat. p. 12.

This large species, which occurs over Northern and Western Australia and New Guinea, is abundant over the whole Monte Bello Group, wherever there are flat sandy plains of sufficient extent. In places the ground is riddled with its flattened burrows, which usually descend to a depth of two feet or so, and ascend again to a second entrance, though they often branch and intersect. The reptile is only in evidence on very hot days, and is generally shy and wary, running with great rapidity. It feeds upon the larger Orthoptera, possibly also upon small birds. On the mainland in this vicinity it is known by the name of 'Bungarra,' derived from the aborigines, amongst whom it forms a source of food. It is supposed to do considerable damage to young chickens and eggs in settled localities.

9. *VARANUS ACANTHURUS*, B. M. Cat. vol. ii. p. 324.*Odatia ocellata* Gray, Cat. p. 8.

This reptile is apparently scarce, for only one specimen was seen, being obtained on a *Spinifex*-plain of Hermite. On the mainland it is found over the north and west of the continent.

10. *TYPHLOPS AMMODYTES*, sp. n. (Pl. I. figs. 8-10.)

Snout rounded and strongly projecting; nostril lateral. Rostral narrow, the upper portion nearly one-third the width of the head, not extending quite to the level of the eyes. Nostril between two nasals, the inferior of which comes just in contact with the lower portion of the præocular. Upper nasal nearly as broad as the rostral. Frontal small, præfrontal and parietals larger than the scales of the body. Eyes distinct. Four upper labials. 20 scales around the middle of the body. Tail slightly longer than broad, conical, ending in a short spine. Colour a uniform pale greyish brown, somewhat lighter on the under surface.

Length 230 mm. Diameter of body, 4 mm.

Found in the sand, under a loose rock, Hermite Island.

This species holds quite an isolated position. In most respects it approaches *T. bramini*, from which it is readily distinguished by the inferior nasal not extending to the upper surface of the head.

# 11. LIASIS CHILDRENI Gray.

Gray, Zool. Miscell. 1842, p. 44; Cat. p. 93; Dum. & Bibr. Erp. Gén. vi. p. 439, 1844.

Only one specimen of this snake was seen and obtained. Apparently it is not common, though probably more in evidence in the very hot weather. It is distributed over Northern Australia to the islands in Torres Straits. I am aware of no previous record so far south as the Monte Bello Group.

From the above list, it will be seen that the reptilian fauna is typically North-West Australian, and it is quite possible that the new *Typhlops* will be found also to occur on Barrow Island and the mainland. With one or two exceptions, however, the island forms have undergone a marked reduction in size.

The following measurements of total lengths illustrate to what extent this reduction has taken place:—

|                           | Brit. Mus. Cat. | Largest specimen obtained. |
|---------------------------|-----------------|----------------------------|
| <i>H. binoei</i> .....    | 80 mm.          | 103 mm.                    |
| <i>G. variegata</i> ..... | 147 "           | 87 "                       |
| <i>P. gilberti</i> .....  | 468 "           | 370 "                      |
| <i>A. muelleri</i> .....  | 85 "            | 49 "                       |
| <i>L. bipes</i> .....     | 57 "            | 82 "                       |
| <i>L. isolepis</i> .....  | 198 "           | 143 "                      |
| <i>V. gouldii</i> .....   | 1300 "          | 1070 "                     |
| <i>V. acanthurus</i> ..   | 665 "           | 69 "                       |

## INSECTA.

The collections of insects from the Monte Bello Islands are small. The islands were worked only during the dry months, when probably not one-third of the species were in the imago state, and it is probable that after the tropical rains very different results might have been obtained. On the other hand, the rainfall is so erratic that there are really no fixed seasons for emergence, and, the average temperature being high, a shower of rain in July may cause the emergence in small numbers of a species occurring abundantly after a heavy storm in October. To this cause I attribute the large percentage of odd examples, for showers occurred in April and in July, after a prolonged period of drought—the tropical rains of the previous season having failed. It is interesting to note, that with the common Pierid butterfly, *Belenois teutonia*, though the majority were of the dry-season form with the black on the margins of the wings reduced, about 20 per cent. were intermediate, and a few examples even approached the wet-season form. The collection, therefore,

may be more representative than might at first be supposed. In any case the number of species inhabiting the islands is likely to be small.

## LEPIDOPTERA.

### Rhopalocera.

Of butterflies frequenting the Monte Bello Islands there are eight species, the majority of which are common and widely distributed forms, though one, possibly two, of the *Lycænids* are distinct island forms. The specimens have been compared with forms in the British Museum.

1. BELENOIS TEUTONIA Fabr.

*Belenois java* Waterhouse, Cat. Rhop. of Australia, no. 1 memoir, N.S.W. Naturalists' Club, 1903.

A well-known Austro-Malayan species, very abundant.

2. PRECIS VELLIDA (Fabr.).

One example of this widely-distributed and rather variable butterfly.

3. VANESSA KERSHAWI McCoy.

Another widely-distributed form, the Australian representative of the familiar *V. cardui*. In the Monte Bello examples, the fifth (anterior) spot on the under surface of the hind wing is much reduced or absent. Though in this respect the Monte Bello series is uniform, yet these spots are generally somewhat variable, and no systematic distinction can be made.

4. DANAIIS CHRYSIPPUS Linn., form *petilia* (Stoll).

An Austro-Malayan form, not uncommon on Hermite.

5. NEOLUCIA SERPENTATA H.-Sch.

The Monte Bello series is again very uniform, and differ from most examples in having only one ocellus at the hind margin of the lower surface of the hind wing. The general coloration of the lower surface is brighter than in specimens from East and South Australia, and less bright and distinct than in specimens from Port Darwin and the tropical North. It is identical with specimens from Wallaby Island in the British Museum collection, and is possibly an island form. Very common over the whole group.

6. NACADUBA BIOCELLATA Felder.

This butterfly extends over Western Australia, being particularly abundant on the islands off the north-west coast. The sets obtained on Hermite, Long and Trimouille Islands are identical with examples from Queen's Islet, N.W.A. The species was very abundant from June to the end of July, frequenting the flowers of *Myoporum*.

7. *HOLOCHILA HEATHII AERATA*, subsp. n.

This is a common Monte Bello form of *H. heathii* Cox. It is somewhat smaller, and the male shows a bronze rather than a purple sheen upon the upper surface of the wings, and is of generally darker coloration. In the female, the blue on the upper surface of the fore wings is much reduced, in some examples being confined to the base of the interspace between the first and second veins. Both sexes have six very distinct marginal spots upon the lower surface of the fore and hind wings, in this respect resembling the type and differing from examples from the south-west and central parts of Western Australia, in which these spots are generally indistinct and sometimes absent.

8. *OXYTOXIA ARGENTEO-ORNATUS* Hew.

A large series, mostly from Hermite.

**Heterocera.**

It is by no means sure that the majority of species in the following list are not accidental visitors to the islands. By far the greater number of the Noctuae were taken upon sugar on one or two evenings, notably June 20th and from June the 29th to the first few days of July, 1912. Though sugar was applied almost every evening throughout our three months' visit, yet it was only upon these few occasions that moths were taken. The nights in question were warm and still, following upon periods of strong easterly and south-easterly winds, which had blown for several days in succession. It would not be surprising that winds of this nature, which several times enveloped the islands in clouds of dust from the deserts of the mainland, should bring with them winged insects capable of fairly prolonged flight. There are, however, several forms which are apparently new, two of which are described here. Other apparently new species require comparison with type-specimens in Australia. As the N.W. Australian fauna is at present but little known, it would be unsafe to base any zoo-geographical conclusions upon insects so easily transported.

1. *AMSACTA MARGINATA* Donov.

Three examples, similar to specimens in the British Museum from the Sherlock River district, including a yellow-bodied aberration, which is also identical in every respect. In the red-bodied specimens, the black spots on the margins of the hind wings are much reduced, whereas in the yellow-bodied specimen they are very prominent.

2. *UTETHEISA PULCHELLOIDES* Hamps.

Identical with specimens from Port Darwin and Baudin Island.

3. *EUPROCTIS CHIONITIS* Turner.

A very abundant species distributed over most of Australia

4. *ANTHELA* Walk. (*Darala* Walk.) *PUDICA* Swinh.

A somewhat dark form of this West Australian species.

5. *COLLUSA* sp. ? near *C. flavala*.6. *EUXOA RADIAN*S.

Distributed all over Australia.

7. *CHLORIDEA ARMIGERA* Hübn.

Agrees with specimens from North Australia, in which the orbital stigma is nearly obsolete.

8. *NEOCLEPTRIA PUNCTIFERA* Walk.

Distributed over Northern and Western Australia.

9. *MELICLEPTRIA NEURIAS* Meyr.

Agrees with the light West Australian form from the Sherlock River.

10. *MELICLEPTRIA ALBIVENATA*, sp. n. (Pl. I. fig. 11.)

Head and thorax light brown; abdomen white below, yellowish above. Fore wings yellowish brown, the veins white, narrowly bordered on each side with dark brown. In some specimens, the wing more or less diffused with scattered white scales, with the exception of the discoidal cell, which stands out rather clearly, and the region near the outer margin. A terminal series of dark points, but often indistinct. Hind wings white, suffused with brown except upon the terminal and costal areas. Expanse, 27 mm.

In general appearance resembles *M. canusina* Swinh. (Hamps., B.M. Cat. vol. iv. p. 99) from the Sherlock River district, but distinguished by the white nervures and suffusion.

Taken on sugar, Hermite, July 1912.

11. *PROPATRIA MUNDOIDES* Lower.

Widely distributed upon the mainland of Australia.

12. *ECTOPATRIA ASPERA* Walk.

Distributed over Australia and New Zealand.

13. *PANDESMIA SUBMURINA* Walk.

Australia and New Guinea.

14. *GRAMMODES OCELLATA* Tepper.

Two typical examples. Distributed over Australia.

15. *GONITIS SUBULIFERA* Guen.

A few examples of this almost cosmopolitan species.

16. *ANUMETA ZUBOIDES*, sp. n. (Pl. I. fig. 12.)

This may prove to be merely a form of *Anumeta zuba* Swinh., to which in any case it is very closely allied. Compared with specimens in the British Museum, the following distinctions are readily observed: somewhat larger in size; the white line across the fore wings in the majority of specimens much more distinct, waved instead of straight; hind wings darker in colour. Expanse, 30 mm.

The specimens were taken on sugar, Hermite, July 1912.

17. *CIRPHIS ABDOMINALIS* Walk.

Recorded from North Australia. Hermite, scarce.

18. *AMYNA OCTO* Guen.

Widely distributed, occurring from India to the New Hebrides.

19. *AMYNA SPILONOTA* Lower.

A North Australian species, recorded from Port Darwin.

20. *EUBLEMMA DUBIA* Butler.

Distributed over the greater part of the Australian continent.

21. *POLYDESMATA LAWSONI* Feld.

Western Australia. Specimens identical with examples from the Sherlock River.

22. *POLYDESMATA MARMARINOPA*.

Also identical with specimens from the Sherlock River.

## COLEOPTERA.

The following very meagre *provisional* list comprises all the beetles found upon the islands, although considerable pains were taken in their collection. Searching the sand and vegetation at night by the aid of a lantern yielded the best results, but there can be few species and those by no means abundant. Of these three appear to be new, but they are not now described, as many type-specimens of West Australian species have not been examined. The list will serve at least to show the type of the fauna.

1. *Trox crotchii* Har. Hermite.
2. *Isodon novitius* Blackb. Hermite.
3. *Coccinella transversalis* Fabr. Hermite.
4. *Dermeestes cadavorinus* Fabr. From a dead Cat.
5. *Gonocephalum meyricki* Blackb. Hermite.
6. *Sympetes*, (?) sp. n. Hermite.
7. *Saragus*, (?) sp. n. Hermite.
8. *Mictotragus arachne* Pascoe. All islands.
9. *Phorocantha*, (?) *senio* Newm. Hermite.
10. *Symphyletes*, (?) sp. n. Hermite.
11. *Bostrychopsis jesuitus* Fabr. All islands.

## ORTHOPTERA.

The Orthoptera, as is usually the case in warm and arid localities, comprise a large and characteristic section of the insect fauna of the Monte Bello Islands. There are few species, but of those that do occur, some are extremely abundant. The larger winged species are mostly of wide distribution, but the smaller wingless forms comprise several undescribed (?) species.

The acridiids include such forms as the large *Cyrtacanthus guttulosa*, which occurs in great numbers upon all the islands, forming the main food-supply of the larger Reptiles. This insect is capable of prolonged flight, though it is only upon rare occasions that it exerts this faculty, and then can be observed flying in swarms through the *Spinifex*, usually about sunset. The 'Blue-winged Locust,' *Coryphistes cyanopterus* Charpentier, also occurred but the examples were mostly of small size. The species is of wide distribution. Another large form, *Acridium maculicollis*, was also recorded, though it was not common.

Of the mantids, only two were met with in numbers, *Archimantis brunneriana* Sauss., a North Australian species, and a smaller species of the genus *Orthoderides*, near *O. ministralis* Fabr., but as yet undetermined. This insect was always found upon the foliage of *Myoporum acuminatum*, the leaves of which it closely assimilates both in form and colour.

Three species of cockroach were obtained, two of them identical with, or closely allied to, *Periplaneta concolor* Walk. and *Ellipsidron inquinata* Walk., and the third apparently a new species of the genus *Polyzosteria*. One female phasmid was also obtained, clearly a form of or closely allied to *Hyrtacus entrachelia* (Westwood).

## HYMENOPTERA.

The species of Hymenoptera from N.W. Australia are little known. Consequently any geographical conclusions based on collections from Monte Bello are likely to be erroneous. The following is a *provisional* list showing the type of the fauna, but the ants have been omitted.

## 1. PARACOLLETES PERFASCIATUS Cock.

This species has been identified by Mr. G. Meade-Waldo, British Museum, who contributes the following note.

"The type of this species, described by Cockerell (Ann. Mag. Nat. Hist. (7) xvii. p. 25, 1906) from a specimen in very poor condition, has 'Western Australia' as its only locality. It may be useful to give a few remarks on the pubescence, which is much spoiled by wetting in the type. For structure, Cockerell's description is excellent. The thorax in fine fresh specimens is densely clothed with brownish-buff pubescence, thickly inter-

mingled with black hairs; the median segment is clothed with whitish pubescence on the surface of the truncation, and the scopa on the posterior tibiae and tarsi is composed of long and dense white hairs. Two females collected on Hermite Island, July 1912."

## 2. *NOMIA FLAVIVIRIDIS*, subsp. *doddi*, Cock.

Also identified by Mr. Meade-Waldo. Another W. Australian species.

3. *Epactrothynnus productus* Turner. Hermite.
4. *Thynnus*, (?) sp. n. Hermite.
5. *Bembex*, (?) *variabilis* Sm. Hermite.
6. *Sphex australis* Sauss. Hermite.
7. *Trachysphex*, (?) *pilosulus* Turner.
8. *Salvis tuberculatus* Sm. Hermite.
9. *Aporus cingulatus* Fabr.
10. *Aporus*, (?) sp. n. Hermite.
11. *Ephutomorpha morosa* Westw. Hermite.
12. *Ephutomorpha modesta* Smith. Hermite, Trimouille.
13. *Henicospilus* sp.?

Of other insects the Hemiptera were not well represented, the majority of forms being Homoptera. Two species of water-bugs were obtained from the Home Lagoon, Hermite, one closely resembling *Hermatobatodes marcheii* Coutière et Martin (Bull. Mus. Hist. Nat. Paris, vii. 1907, p. 214) and the other *Halobates wulterstorffi* (Frauenf.)\*; both appear to have points of specific difference.

## MYRIAPODA.

Identified by Professor K. Kraepelin.

The species are all forms found upon the West Australian mainland, though one is apparently an insular variety. The specimens were largely collected from under stones during the daytime, but some were found running about in the sand by the aid of a lantern at night.

### 1. *RHOMBOCEPHALUS LETUS* Haase.

*Scolopendra lata* Haase, Abh. Mus. Dresden, No. 5, p. 51, pl. iii. fig. 51 (1887).

Recorded from Western Australia and New South Wales. Fairly numerous on Hermite.

### 2. *RHOMBOCEPHALUS MORSITANS* (Linn.).

(*Scolopendra morsitans* Linn.)

Probably imported from Asia by way of the mainland, where it is now established. The species is now almost universally distributed in the warmer parts of the world.

\* Cf. F. B. White, 'Challenger' Report, p. 40.

3. *CORMOCEPHALUS TURNERI* Pocock.

Pocock, *Annals & Mag. Nat. Hist.*, 7th Series, vol. viii. p. 456 (1901).

Three examples, taken on Hermite, differ from the type from Perth, Western Australia, in that the last tergum has a distinct median groove, which is lacking in the mainland form.

4. *ASANADOPSIS MJÖBERGI* Kraepelin.

At the time of writing, Professor Kraepelin's description of this species, which was sent to him by Dr. Mjöberg from North-Western Australia, was not yet published. Professor Kraepelin considers this second example from Hermite to be identical, though he could not be absolutely certain, for he had sent back the type and was consequently unable to compare the two.

One species of scorpion was obtained on Hermite. It is identified by Dr. Kraepelin as *Lychas variatus* Thor.

## PISCES.

The following fishes are inhabitants of the tidal lagoons. They have been identified by Mr. C. Tate Regan.

1. *Orectolobus tentaculatus* Peters.
2. *Rhinobatus armatus* Gray.
3. *Muraena thyrsoidea* Richards.
4. *Plotosus anguillaris* Bloch.
5. *Choroichthys valenciennei* Kaup.
6. *Pseudochromis fuscus* Müller & Trosch.
7. *Valenciennaea longipinnis* Bann.
8. *Gobius phalaena* Cuv. & Val.
9. *Opsanus diemensis* Lesueur.

## SUMMARY AND CONCLUSIONS.

In considering the relation between these islands and the mainland, a feature of primary importance is the extreme shallowness of the sea between them and the mainland, in all probability indicating a separation of comparatively recent date. The invertebrate fauna of Barrow Island is unfortunately little known. The identity of the Wallaby, *Lagorchestes conspicillatus*, and the Bandicoot, *Isodon barrowensis*, support the theory that Barrow and the Monte Bello Group were continuous long after their separation from the mainland.

The fauna, however, is not typical North-West Australian, such as is met with in the Ashburton district, but comprises many Northern and South-Western forms. There are, furthermore, few species, and these are of mixed distribution. Many characteristic North-Western forms are entirely absent, though a high percentage of those species not easily transported (such as the Reptiles and Chilopoda) are identical with, or slightly modified representatives of, the species occurring in the immediate vicinity upon the mainland. Mr. Hogg, in dealing with the spiders, has

pointed out the absence from the collections of several species so widely spread as to be generally found in any locality in Australia. He suggests, therefore, that the islands have once been largely denuded of the original spider fauna, and were repopulated subsequently with other species. These seem mostly to have come from the south-west by the trade-wind course, for the majority could certainly have been wind-borne. These remarks in some measure seem to apply to other groups of animals, though many species are northern, occurring in Queensland and the Northern Territory, probably having come down by the hurricane course.

That an almost complete depopulation of the islands could have occurred is by no means an improbability, when their small size and the prevailing meteorological conditions are considered. It will be noted that the vast majority of the specimens recorded are from Hermite. This island was certainly the most thoroughly worked, though the others were frequently visited, but its fauna was at least three times as large as that of any of the smaller islands. This is merely a demonstration of the obvious fact that the smaller the island, the less will be the chance of a sufficient number of individuals surviving to perpetuate the species after a particularly severe and prolonged period of drought. It is indeed remarkable that the Wallaby has been able to survive, considering that it lives entirely in the open, and has nowhere to shelter except amongst the *Spinifex* during the hurricanes, when trees and bushes are torn up by their roots, and sand and shells blown about with such violence as to cut deeply into wood.

In considering this point, it is well to remember that little work has been done in the North-West of Australia, and the distribution of some species may be found to be much more extended than is at present supposed. Moreover, other forms, which might be looked upon as island species, may really be quite common on the mainland, though as yet unrecorded. However, the well-known generalisations with regard to island faunas (using the word 'island' in the zoological sense) hold good:—the wingless forms not easily transported comprise most of the undescribed forms, being in many instances clearly the modified representatives of mainland species, whereas the easily transported winged species are for the most part of wide distribution. There are many anomalies, which can only be explained by considering individually the habits of each species and the prevailing meteorological conditions. Amongst the Longicorn beetles, for example, there are two abundant species, of which one, *Mictotragus arachne*, has the elytra completely fused, and is absolutely identical with the form occurring abundantly upon the mainland opposite. The other, *Symphyletes*, sp. n. (?), a form with well-developed wings, is confined to Hermite. A possible factor in such local distributions is perhaps to be looked for in the whirlwinds which are a characteristic weather-feature of the district. These disturbances can be observed almost any day, and must certainly be regarded as an important distributing factor. Of the two beetles in question, the

*Mictotragus* is almost invariably found walking about freely upon the surface of the sand, and has an extremely thick and hard cuticle, being therefore well adapted for wind transportation. The *Symphyletes*, on the other hand, was only found upon its particular plant, *Tricholesma zeylanicum* R. Br., clinging to the stems just below the clusters of flowers and buds, from which it was not easily dislodged.

Of the birds, one new subspecies, *Eremiornis carteri assimilis*, is a bird of very weak flight, seldom fluttering more than a few yards at a stretch, and taking shelter in the densest thickets. It is therefore not surprising that it should differ from its mainland representative. In the subspecies of *Anthus australis*, however, the case is different, for it is a bird of powerful flight, often observed crossing the passages between islands, and inhabiting the open plains. It is surprising that this bird should exhibit even more marked differences from the mainland form than the last-named.

#### EXPLANATION OF THE PLATES.

##### PLATE I.

###### *Heteronota binoei*.

- Figs. 1, 2. Showing variation in markings.  
3. Individual with regenerating tail.

###### *Physignathus gilberti*.

4. Male, nat. size.  
5. Under surface of head, showing general outline and gular fold.  
6. Female, nat. size.  
7. Under surface of head of female.

###### *Typhlops ammodytes*, sp. n.

8. Head, dorsal view.  
9. Head, ventral view.  
10. Tail, ventral view.  
11. *Melicleptria albivenata*, sp. n., nat. size.  
12. *Anumeta zuboides*, sp. n.

##### PLATE II.

Young *Pandion haliaëtus melvillensis* in nest.

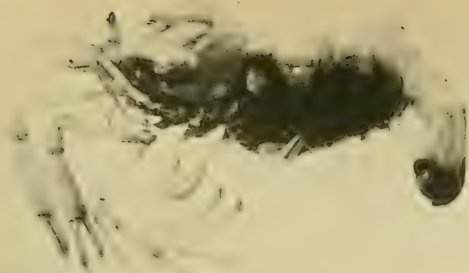
##### PLATE III.

Nest and young of *Haliaëtus leucogaster*.

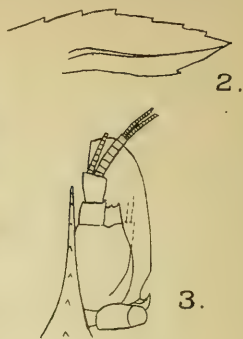
##### PLATE IV.

Home Lagoon and Vegetation of Hermite Island.



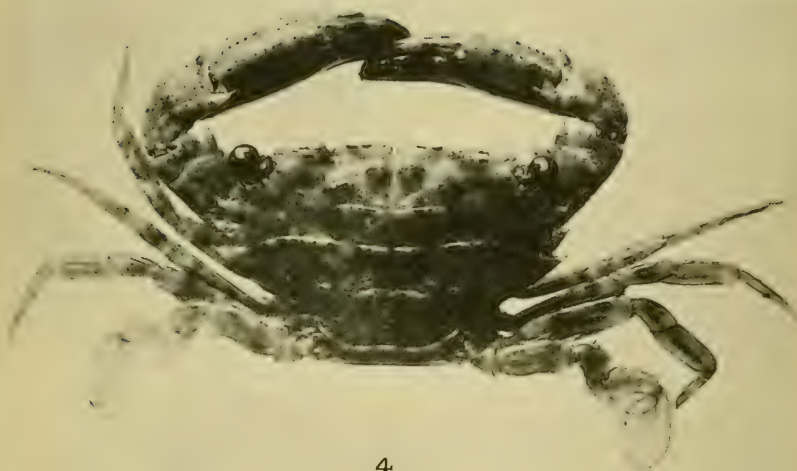


1.



2.

3.



4.



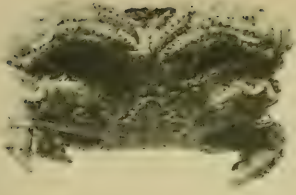
5.



6.

Huth, London.

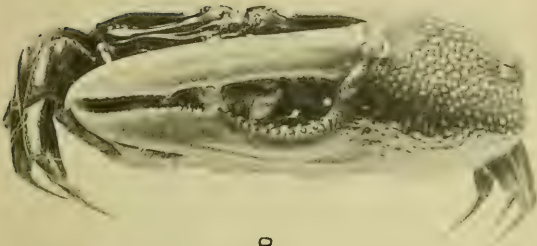




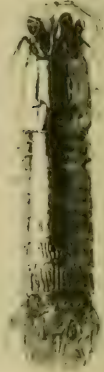
7.



9.



8.



11.



12.



10.

Huth, London.

36. Stalk-eyed Crustaceans collected at the Monte Bello Islands. By MARY J. RATHBUN, United States National Museum, Washington, D.C., U.S.A.\*

[Received March 18, 1914: Read June 9, 1914.]

(Plates I., II.†)

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| <i>Periclimenes hermitensis</i> , sp. n. .... |        | 655  |
| <i>Thalamita dispar</i> , nom. n. ....        |        | 657  |
| <i>Actæa glandifera</i> , sp. n. ....         |        | 658  |
| <i>Glyptoxanthus cymbifer</i> , sp. n. ....   |        | 658  |

This little collection, numbering only 28 species, contains three new species and variations of several old ones. Incidentally a new name is given to one of the numerous forms of *Thalamita* related to *T. admete*, which in time can perhaps be lined up as subspecies or varieties of that species. The most notable of the new species is the *Glyptoxanthus*, a genus new to the Indo-Pacific region.

A remarkable discovery is the fact that at least one of the marine crabs, *Naxioides serpulifera*, undergoes transformation to the adult form while it is still within the brood-pouch of the mother. Furthermore, it there passes through two adult stages, but whether the first is hatched directly from the egg or not, it is impossible to tell. It has long been known that the fresh-water crabs (Potamonidæ) develop into the adult form before leaving the mother, and in some cases at least pass through a megalops stage. Careful researches into the metamorphoses of marine crabs would doubtless disclose other cases similar to that here recorded.

# Order DECAPODA.

## Family PENEIDÆ.

### METAPENEUS MONOCEROS (Fabricius)‡.

*Metapeneus monoceros* Alcock, Catal. Ind. Dec. Crust. Ind. Mus., Part iii. Fasc. i. 1906, p. 18, pl. iii. figs. 7-7c.

Dredged off Hermite; 2 fathoms; July 7, 1912; No. 110: 1 ♂ juv., about 47 mm. long.

### METAPENEUS STRIDULANS Alcock?

*Metapeneus stridulans* Alcock, Catal. Ind. Dec. Crust. Ind. Mus., Part iii. Fasc. i. 1906, p. 27, pl. v. figs. 14, 14 a-d, and synonymy.

\* Communicated by Prof. J. STANLEY GARDINER, M.A., F.R.S., F.Z.S.

† For explanation of the Plates see p. 664.

‡ [The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature (Proc. 7th Int. Cong. Boston, 1907, p. 44 (1912)).—EDITOR.]

Monte Bello Islands; special locality not given: 1 ♀.

In the main, this specimen agrees with Alcock's description and figures. There are 17 ridges in the stridulating organ near the posterior corners of the carapace. The telson and the thelycum differ from typical *stridulans*. The telson has 5 (not 4) pairs of marginal spines, 4 pairs of which are movable, and the posterior pair immovable. The thelycum has the plate between the legs of the fifth pair similar to that in fig. 14*d*, *loc. cit.*; the plate between the legs of the fourth pair is trilobate or in the shape of a clover-leaf; the bar between those two plates is longer (from front to back) and narrower than the same plate in Alcock's figure.

On p. 50 of his Catalogue (*op. cit.*), Dr. Alcock suggests the identity of my *akayebi* with *stridulans*. *M. akayebi*, however, is quite distinct; the body and rostrum are more slender, the teeth on the latter more prominent; the antennal, hepatic and branchiostegal spines are larger; the second and third segments of the antennular peduncle are longer and more slender; subterminal prominence on carina of fifth abdominal segment obtusangular, not dentiform; sixth segment longer and narrower than in *stridulans*. The thelycum is similar to that of the female from the Monte Bello Islands.

#### Family CRANGONIDÆ (=Alpheidæ).

##### CRANGON EDWARDSII (Audouin).

*Alpheus edwardsii* de Man, Jour. Linn. Soc. London, Zool., vol. xxii. 1888, p. 266, and synonymy.

Home Lagoon, Hermite; Aug. 12, 1912; No. 140; 1 ♀ ovig., 51 mm. long.

Monte Bello Islands; special locality not given; 2 specimens; the larger one lacks both pairs of chelipeds, the smaller one lacks the larger cheliped of the first pair.

The two specimens possessing chelipeds of the second pair belong to the variety in which the first and second joints of the carpus are of the same length. The larger of these specimens shows a faint notch in the upper margin of the smaller manus of the first pair.

##### CRANGON BUCEPHALUS (Coutière), var.

*Alpheus bucephalus* Coutière, Alpheidæ in Gardiner's Mald. & Laccad. Archip., 1905, p. 890, pl. lxxviii. figs. 29-29*f*; De Man, Alpheidæ 'Siboga,' 1911, p. 316.

Dredged off Hermite; sandy bottom; July 9-12, 1912; No. 109: 1 ♂, about 12.5 mm. long.

The differences between our specimen and the type are so few that the former probably represents no more than a variety of the latter. The specimen in hand is considerably larger than the

type; it has not so long a rostral tooth, and consequently the sinuses between that tooth and the orbital prominences are not so deep; the antennal peduncle is not so long as in Coutière's fig. 29, although it is a little longer than the antennular peduncle; the merus of the larger cheliped has a tooth at the lower distal angle, not unlike the tooth shown in Coutière's fig. 29 *a'*, but he says (p. 821) "le méropodite est inerme," and in the figure, the tooth is applied against the carpus so that it is inconspicuous.

### Family PALÆMONIDÆ.

#### Subfamily Pontoniinæ.

*PERICLIMENES HERMITENSIS*, sp. n. (Pl. I. figs. 1-3.)

Hermite; under rock; Aug. 17, 1912; No. 159, 1 ♀ ovig.

*Dimensions.* Type ♀, length from tip of rostrum to tip of telson, approx., 39 mm.; length of carapace, 14 mm.

A *Periclimenes* with thorax strongly arched from front to back as well as from side to side. Rostrum reaching to middle of third segment of antennular peduncle, compressed, thin; upper margin convex, armed with six teeth, the posterior of which is slightly behind the orbit; tip acute; lower limb shallower than upper, margin slightly convex, unidentate. An antennal and hepatic spine present; no supraorbital spine. Branchiostegal angle of carapace rounded. Eyes small. Scale of antennulæ narrow-ovate, reaching nearly to end of second segment, basal spine curved, acuminate. Peduncle of antennæ reaches just to end of first segment of antennulæ, basal spine small; scale ovate-oblong, most produced at inner angle, its outer spine small, scale reaching beyond the peduncle of the antennulæ but not so far as their flagella; the flagellum of the antennæ when bent back reaches half the length of the abdomen.

The added lengths of the last two articles of the third maxilliped exceed that of the antepenultimate article. The chelipeds of the first pair when extended reach beyond the acicle by the length of their chelæ; merus and carpus subequal, manus  $1\frac{1}{2}$  times as long as fingers and  $\frac{3}{8}$  as long as carpus. Chelipeds of second pair subequal, reaching beyond the acicle by the length of the chelæ; merus cylindrical, unarmed; carpus cup-form, a large V-shaped notch in the lower, outer portion of the distal margin; manus subcylindrical, gradually widening a little distally; fingers nearly as long as palm, prehensile edges entire and meeting or overlapping when closed except at the base, where there is a very low tooth on the fixed finger between two similar ones on the dactylus; tips spiniform, turned sharply toward each other.

The dactyli of the third, fourth and fifth feet are short (about  $\frac{1}{6}$  as long as the propodi), curved; lower margin convex at the base, but without spines or other protuberance.

The first three segments of the abdomen are very broad; sixth segment not much longer than wide and  $\frac{2}{3}$  as long as the telson;

the latter is triangulate, with nearly straight sides, and an obtuse angled tip armed with three pairs of spinules, of which the intermediate pair is longest and the outer pair shortest. Uropods broad-oval, longer than the telson, the outer pair broader and a very little longer than the inner pair.

*Colour.* The specimen, which is preserved in formalin and glycerine, is handsomely marked with lines of crimson and purple; on the pleura of the first three abdominal segments there are four incomplete oval areas partly outlined with narrow crimson stripes; the same colour forms a ring on the end of each uropod, the inner ring smaller than the outer; the tip of the telson is also outlined in the same colour; within these five areas of the tail-fan, the colour is a lighter yellowish-red. Dorsal face of carapace a brownish-orange. Chelipeds of second pair with a narrow stripe of purple at the distal end of the merus, carpus and manus, and a more crimson stripe on the distal half of the fingers. The third, fourth, and fifth feet have similar purple stripes on the three principal segments.

This species is not very nearly related to any other. It has the same rostral formula,  $\frac{6}{1}$ , as *P. parvus* Borradaile (see Willey, Zool. Results, Part iv. 1900, p. 407, pl. xxxvi. figs. 3-3c), but that species is more slender, with lower rostrum and larger eyes.

#### ANCHISTUS INERMIS (Miers).

See Borradaile, Ann. Mag. Nat. Hist. (7) vol. ii. 1898, p. 387.

Hermite, in mantle-cavity of *Pinna*; July 7, 1912; No. 112: 1 ♀ ovig., about 26 mm. long.

This corresponds in the main with the description and figures given by Miers (Crust. 'Alert,' 1884, p. 291, pl. xxxii. figs. B, b, b'). In the Hermite specimen, the telson has at the end four setæ, the outer pair stouter than the slender inner pair but nearly as long; Miers's fig. b shows five setæ, one median and two lateral pairs, the outer pair about half as long as the inner. The smaller cheliped of the second pair in our specimen has the tooth on the dactylus feebly developed, and fitting into a cavity in the fixed finger; in Miers's type this tooth was not developed, but the specimen was smaller.

Miers described the species from Port Molle, Queensland; he also had a specimen taken from a *Pinna* at Sharks Bay, West Australia.

#### Family PAGURIDÆ.

##### DARDANUS MEGISTOS (Herbst).

*Pagurus punctulatus* Alcock, Catal. Ind. Dec. Crust. Ind. Mus., Part ii. Fasc. i. 1905, p. 81, pl. viii. fig. 1.

One specimen, of medium size. The species is distributed throughout the Indo-Pacific region.

## Family PORTUNIDÆ.

THALAMITA DISPAR, nom. n. (Pl. I. fig. 4.)

*Thalamita savignyi* de Man (not A. Milne-Edwards), Zool. Jahrb., Syst., vol. viii. 1895, p. 564.

Monte Bello Islands; 3 ♂.

*Dimensions.* Type and largest ♂: length of carapace 15.2 mm.; width 25.4 mm.

This is the same species as that described by de Man (*loc. cit.*), for I have at hand for comparison one of his specimens from Palos Bay, West Celebes; but it cannot be the true *savignyi* of A. Milne-Edwards (Arch. Mus. Hist. Nat. Paris, vol. x. 1861, p. 357), because in the figure of this in Savigny's 'Égypte' (Crust. pl. iv. fig. 4) the inside of the hand shows coarse granules.

Carapace pubescent except on the elevated ridges. These are prominent; the posterior one across the cardiac region with a small piece on the branchial region, though bare and elevated, lacks the distinct granulated edge which characterizes the other ridges. Lobes of front separated by an open median slit. Fourth tooth of lateral margins absent. Five crests on upper and outer surface of palm, the two uppermost crests each with three spines, of which the terminal one is short and subacute; third crest tuberculate, fourth and fifth obscurely granulate, the fifth very finely so; the first three interspaces each with some coarse granules and also pubescent; in the smallest of the three specimens, the third interspace is smooth; there may be a line of pubescence above the lowest crest but it is not constant.

The above characters suffice to differentiate this from other members of the *admète* group.

The Celebes specimen is an adult female smaller than any of the males. It differs from them in having a very shallow and small median emargination in the front. There is a minute rudiment of a fourth lateral tooth on the right side only.

## Family XANTHIDÆ.

CARPILODES RUBER A. Milne-Edwards.

*Carpilodes ruber* A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. Paris, vol. i. 1866, p. 228, pl. xi. figs. 4-4b.

Without special locality; 2 ♀ immature, 13 mm. and 14.4 mm. wide. They retain a deep crimson colour in alcohol.

Home Lagoon, Hermite; under stones; July and August, 1912; No. 108: 3 ♀ (1 mature, 2 young).

ATERGATIS OCYROË (Herbst).

*Atergatis floridus* Alcock, Jour. Asiat. Soc. Bengal, vol. lxvii. 1898, p. 98.

Without special locality: 1 ♂, 1 ♀ juv.

## PLATYPODIA GRANULOSA (Rüppell).

*Lophactæa granulosa* Alcock, Jour. Asiat. Soc. Bengal, vol. lxvii. 1898, p. 101.

Without special locality: 3 ♂, 2 ♀, 2 juv.

## ACTÆA AFFINIS (Dana).

*Actæodes affinis* Dana, Crust. U. S. Expl. Exped., vol. i. 1852, p. 197; Atlas, 1855, pl. xi. fig. 3.

Home Lagoon, Hermite; under stones; July 1912; No. 105: 1 ♂.

## ACTÆA GLANDIFERA, sp. n. (Pl. I. fig. 5.)

*Type-locality.* Monte Bello Islands: special locality not given; 2 ♂, 1 ♀ (1 ♂ is type).

*Additional locality.* Home Lagoon, Hermite, under stones; July 1912; No. 107: 1 ♂, 1 ♀.

*Dimensions.* Type ♂, length 8.4 mm., width 12 mm.

Closely related to *Actæa spinosissima* Borradaile\*, from which it differs in the character of its tubercles and spines rather than in their position. The tubercles of the dorsal surface are broad and arcuate as in *spinosissima*, but are thicker and less flattened and less petaloid, those toward the lateral margins being acorn-shaped. This is also the form of the five antero-lateral spines behind the orbit; in *spinosissima* they are long spines. The projections of the front are simply crenulations, not spines nor spiniform teeth. Spines of chelipeds short, stout, acorn-shaped, and directed a little forward as are those on the carapace. The spines on the legs are longer than on the chelipeds and are stout and subacute, not slender and elongate as in *spinosissima*.

Although the five specimens are all larger than any specimen of *spinosissima* yet recorded, there is no indication of intergrading from one species to the other.

## GLYPTOXANTHUS CYMBIFER, sp. n. (Pls. I., II. figs. 6, 7.)

*Type-locality.* Monte Bello Islands; no special locality given: 2 ♂ (1 is type), 1 ♀.

*Dimensions.* Type ♂, length of carapace 10.6 mm., width of same 17 mm. Paratype ♀, length of carapace 12.7 mm., width of same 20 mm.

The carapace is closely covered with small bead granules, and is deeply areolated; the protogastric regions are divided into two oblong lobules by a longitudinal furrow; the branchial region bears about six lobules of irregular size, the two next the inner angle of the region being connected by a posterior elevation. There are four small tuberculiform teeth on the lateral margins

\* In Gardiner, Fauna Mald. & Laccad. Arch. i. Part 3, 1902, p. 256, text-fig. 55.

behind the angle of the orbit; they are widely separated by a granular rim; all these teeth except the posterior one are above the true margin, which inclines downward toward the angle of the buccal cavity, as in all the members of this genus. The frontal lobes are obliquely truncate, and separated by a broad, shallow V.

The upper-outer surface of the carpus and the upper surface of the manus are occupied by deep, more or less rounded cavities, with rims which are microscopically granulated but appear smooth in relation to the general granulation of the body. The blackish-brown colour of the fingers runs far back on the lower part of the palm in the male, but is confined to the digits in the female; their granules are set in a felt-like background.

The ambulatory legs are remarkable in having the upper surface of the carpal and propodal segments each occupied by a deep cavity bordered on the posterior margin by a thin rim, somewhat resembling a longitudinal section of a serpulid tube, and on the anterior margin by a thick band of pointed granules irregularly placed.

Lower surface of crab hairy, the hairs of two kinds, one fine, the other coarse, but both soft.

*Glyptoxanthus* has hitherto been known only from the coasts of middle America, West Africa, and the Cape Verde Islands.

*G. erosus* (Stimpson) from the West Indian region attains a width of about 4 cm. When small, about the size of these specimens of *G. cymbifer*, it has a granulated surface; with age the granules wear down smooth, giving it a much more eroded appearance.

Our species differs from all the other described species in the curious hollows or cups on the chelipeds and legs.

#### XANTHIAS ATROMANUS (Haswell).

*Xanthodes atromanus* Haswell, Catal. Austral. Crust. 1882, p. 49, pl. i. fig. 1.

Home Lagoon, Hermite; June 1912; No. 106: 3 ♀ ovig., varying from 8.7 mm. to 13.6 mm. in width.

#### PHYMODIUS UNGULATUS (Milne-Edwards).

For variations, see *Phymodius unguatus* Rathbun, Mem. Mus. Comp. Zool. vol. xxxv. 1907, p. 46, pls. iii. & iv.

Monte Bello Islands: 1 ♀ immature.

Length of carapace 8 mm., width 11 mm.; width of front, orbital angle excluded, 4 mm.

In this specimen the areoles of the carapace are very much subdivided, the lateral marginal lobules obtuse except the last which has a very short spinule at the tip, the chelipeds are subequal, the palms have subparallel margins and acute tubercles, the fingers are slightly curved and have a narrow gape.

*PILUMNUS VESPERTILIO* (Fabricius).

*Pilumnus vespertilio* Alcock, Jour. Asiat. Soc. Bengal, vol. lxvii. 1898, p. 192, and synonymy.

Under stones, Home Lagoon, Hermite; July 1912; No. 106 :  
1 ♀.

*PILUMNUS CÆRULESCENS* A. Milne-Edwards, var.

? *Pilumnus cærulescens* Alcock, Jour. Asiat. Soc. Bengal, vol. lxvii. 1898, p. 196; Rathbun, Kgl. Danske Vidensk. Selsk. Skrifter, 7 Række, naturv. og mathem., vol. v. p. 355, pl. i. fig. 15.

Under stones, Home Lagoon, Hermite; July 1912; No. 106 :  
1 ♂.

*Dimensions.* Length of carapace 12.6 mm., width 16.8 mm.

This is the same form as that which I recorded from the Gulf of Siam (*loc. cit.*). The specimen is considerably larger than any examined at that time, and some of the features are more sharply marked. Although all of the regions are ornamented with granules, they are not closely placed. The outer dentiform lobe of the front is separated from the rest of the front by a U-shaped gap. The two emarginations in the upper border of the orbit are well marked. The antero-lateral projections and also the subhepatic one are well developed spines; the orbital and subhepatic spines are shorter than the other three; these last have a stout base and form at the middle a shoulder from which a cluster of hairs proceeds. A striking feature of the cheliped is the presence on the upper margin of the merus of two strong white spines, one terminal, the other subterminal and larger. The carpus is armed with short, stout spines, the manus with granules; neither spines nor granules are closely placed, and the granules are absent from the lower distal corner of the larger palm. The ornamentation of the whole upper surface is obscured by the coarse hairs of uneven length.

The colour in formalin and glycerine is brownish; the carapace has a ground of yellowish-brown, overlaid with patches of reddish-brown; upper surface of legs with two patches of brownish-red on the merus, the carpus, and the propodus.

*ACTUMNUS SETIFER* (de Haan).

*Actumnus setifer* Alcock, Jour. Asiat. Soc. Bengal, vol. lxvii. 1898, p. 202.

Monte Bello Islands: 1 ♂.

The areolæ of the undenuded carapace are high and very deeply separated and the lateral teeth very prominent; otherwise this individual does not differ from typical specimens from Japan.

## Family OCYPODIDÆ.

## Subfamily Ocypodinæ.

UCA FORCIPATA (Adams & White). (Pl. II. fig. 8.)

*Gelasinus forcipatus* Adams & White, Zool. 'Samarang,' Crust. 1848, p. 50.

3 ♂, large, medium, and small.

The cheliped of the largest specimen has the large distal tooth of the dactylus at more than  $\frac{1}{3}$  the distance from the tip; in the medium specimen, the tooth is at just the distal third. In the smallest specimen this tooth is absent, the specimen representing "form 2" of the species.

## Subfamily Mictyrinæ.

MICTYRIS LONGICARPUS Latreille.

*Mictyris longicarpus* Alcock, Jour. Asiat. Soc. Bengal, vol. lxix. 1900, p. 384, and synonymy.

Monte Bello Islands: 10 ♂, 2 ♀.

## Family INACHIDÆ.

## Subfamily Acanthonychinæ.

HUENIA PROTEUS (de Haan).

*Huenia proteus* Alcock, Jour. Asiat. Soc. Bengal, vol. lxiv. 1895, p. 195, and synonymy.

Dredged off Hermite; July 12, 1912; No. 115; 1 ♀ immature.

## Subfamily Pisinæ.

HYASTENUS ORYX A. Milne-Edwards.

*Hyastenus oryx* Alcock, Jour. Asiat. Soc. Bengal, vol. lxiv. 1895, p. 214, and synonymy.

Under stones in 'lagoons'; June to Aug., 1912; No. 114: 1 ♀ juv.

NAXIOIDES SERPULIFERA (Guérin). (Pl. II. figs. 9, 10.)

*Pisa serpulifera* Guérin, Icon. Règne Anim., Crust. pl. viii. figs. 2, 2 a, 2 b, 2 d.

*Naxia serpulifera* Milne-Edwards, Hist. Nat. Crust., vol. i. 1834, p. 313.

Monte Bello Islands: 1 ♀ mature.

Under stones in 'lagoons,' June to Aug., 1912; No. 114: 1 ♀ juv.

*Dimensions.* Length of carapace of large female to end of horns, 92 mm.; width, exclusive of spines, 59 mm.

An elongated sponge covers the upper surface of the right

rostral horn, and two other sponges are growing on the gastric region.

The abdominal cavity is filled with young crabs in the adult state. The cavity is about 40 mm. wide, 39 mm. long, and about 20 mm. high at the greatest extent; the abdominal appendages are very slender, so that the bulk of the space is occupied by the young, which number 162. These represent two stages, those of the first or earlier stage being 13 in number with carapace about 3.5 mm. long; while those of the next or older stage are 149 in number and about 5.7 mm. long.

The younger ones although thin-shelled are harder and more opaque than the next stage, and correspond to what is known along the Atlantic coast of the United States as "paper-shell" crabs; they are covered with minute red pigment spots; the carapace is almost smooth and naked, its shape is oblong, not subtriangular as in adults; the postocular tooth is well-formed, triangular and separated by a shallow sinus from the supraocular eave; this latter shows no trace of a spine; as to the tip of the rostrum, the inner of the two spines is well-developed and forms the true end of the horn; on its outer side there is a faint prominence, which is later to become the strong lateral spine of the adult; the eyes are large, protruding, the cornea of a light brownish-red colour.

By the next moult, which takes place within the brood-pouch of the mother, the crab increases by more than half its former size, and undergoes several notable changes. The carapace is of similar form, but the whole integument is soft and devoid of colour spots; it is no longer smooth and naked, but uneven and covered with crowded tubercles or granules, with the beginnings of the more prominent tubercles of the adult: the surface is more or less hairy, there being clusters of hooked hairs as in the adult, and above all, a row on each rostral horn which is continued back on the carapace proper; the postocular cup forms a tooth which is separated by a triangular sinus from the supraocular eave, which last is armed with a small spine; rostral horns elongate, each armed with two subequal spines. In the adult, the postocular cup is separated from the supraocular eave only by a closed fissure. This indicates that *N. serpulifera* is generically removed from the other *Naxioides* and should be placed in the neighbourhood of *Lissa* Leach (Zool. Misc. vol. ii. 1815, p. 69).

### Subfamily Schizophrysinæ.

#### SCHIZOPHRYS DAMA (Herbst).

*Cancer dama* Herbst, Naturg. Krabben u. Krebse, vol. iii. part 4, 1804, p. 5, pl. 59. fig. 5.

*Schizophrys dama* Miers, Challenger Rept. vol. xvii. part 49, 1886, p. 67. Alcock, Jour. Asiat. Soc. Bengal, vol. lxiv. 1895, p. 245 and synonymy, but not "*Schizophrys aspera*, p. pt."

Milne-Edwards, given in Kossmann's synonymy; Illus. Zool. 'Investigator,' Crust. Part vi. 1898, pl. xxxv. figs. 2, 2a.

Under stones in 'lagoons'; Monte Bello Islands; June to Aug., 1912; No. 114: 1 ♀ juv. 20.3 mm. long, including rostrum, 14 mm. wide.

This specimen already shows the second or posterior spine on the outer margin of the rostral horn; it is considerably smaller than the anterior spine. It is not shown in the 'Investigator' figure.

*Distribution.* Straits of Malacca (*Alcock*); West Australia, 3 to 5 fathoms (*Miers*).

#### FAMILY PARTHENOPIDÆ.

PARTHENOPE (*Rhinolambrus*) PELAGICA (Rüppell).

*Lambrus* (*Rhinolambrus*) *pelagicus* Alcock, Jour. Asiat. Soc. Bengal, vol. lxiv. 1895, p. 267, and synonymy.

Home Lagoon, Hermite; June 13, 1912; No. 103 a: 1 ♂.  
Special locality not given: 1 ♂.

#### Order STOMATOPODA.

PROTOSQUILLA TRISPINOSA (Dana). (Pl. II. figs. 11, 12.)

See Borradaile, in Willey's Zool. Results, Part iv. 1902, p. 400.

Dredged off Hermite, 3 fathoms; in hole in piece of rock; July 7, 1912; No. 111: 1 ♀.

Special locality not given: 1 ♀, variety.

Length of larger specimen (variety) 41 mm., of smaller specimen 25 mm.

The smaller specimen agrees with Borradaile's amended description and figure, except that the fourth abdominal segment is corrugated much as the fifth is, only more faintly; the sides of the first, second, and third segments are also lightly carinated with three or four smooth ridges.

The larger specimen, which I take to be the same species, has some curious differences. The fourth abdominal segment and the sides of the first, second, and third are nearly smooth, which brings the specimen nearer to Borradaile's, which was of the same size. The fifth segment is bordered posteriorly by fine spinules. On the sixth and seventh segments, the spinules are shorter and stouter than in the small specimen, telson considerably wider than long, its three knobs less circular than in Borradaile's figure and in our small specimen, the outer knobs pear-shaped, the inner one subtriangular; the marginal lobes are not curved inward and are separated by shorter slits than in the smaller specimen; there is a carina parallel to the lateral margin, armed like the margin with spinules.

*Colour-markings.*—The specimens are preserved in formalin and

glycerine. The larger one has small brownish spots regularly arranged in transverse rows: two pairs on the carapace, one pair anterior, one pair more widely separated, at the middle, and a row of four on the posterior half; a row of four on the sixth thoracic segment, and the first, third, and fourth abdominal segments; a row of two on the second, fifth, and seventh abdominal segments. Knobs on telson olive-green, mottled. Uropods with a broad band of reddish-brown across the middle. Swollen part of chela white. The spotting of the smaller specimen is not so distinct and there are in addition many finer, branched spots down the middle of the animal, much as in Borradaile's figure.

*GONODACTYLUS CHIRAGRA* (Fabricius) var. *SMITHII* Pocock.

See Borradaile, in Willey's Zool. Results, Part iv. 1902, p. 400.

Home Lagoon, Hermite, under rock; July 13, 1912; No. 117a:  
1 ♀.

This is the variety (Borradaile, *loc. cit.*), in which the keels of the sixth abdominal segment and telson are considerably compressed; the keels of the sixth segment are produced without constriction into long spines; the upper edge of the middle keel of the telson is produced backward into a spine; and the flukes of the anchor are formed by two narrow ridges running forward from the hinder end of that keel. The dark spots on the first five abdominal segments are not visible as the whole body is very dark in the preserved specimen except the swollen part of the chelæ, that of the manus being a deep blue, and of the dactylus a pinkish-red.

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. *Periclimenes hermitensis*, type ♀, side view,  $\times 2$ .  
2. *Periclimenes hermitensis*, type ♀, rostrum, side view,  $\times 5\frac{1}{2}$ .  
3. *Periclimenes hermitensis*, type ♀, rostrum and antennæ, dorsal view,  $\times 4\frac{1}{2}$ .  
4. *Thalamita dispar*, type ♂, dorsal view,  $\times 2$ .  
5. *Actæa glandifera*, type ♂, dorsal view,  $\times 3$ .  
6. *Glyptoxanthus cymbifer*, ♀, dorsal view,  $\times 2$ .

PLATE II.

- Fig. 7. *Glyptoxanthus cymbifer*, type ♂, ventral view,  $\times 2$ .  
8. *Uca forcipata*, showing outer surface of chela of largest ♂,  $\times 1\frac{1}{2}$ .  
9. *Naxioides serpulifera*, young, first stage,  $\times 12$ .  
10. *Naxioides serpulifera*, young, second stage,  $\times 12$ .  
11. *Protosquilla trispinosa*, ♀, dorsal view,  $\times 2$ .  
12. *Protosquilla trispinosa*, variety, ♀, dorsal view,  $\times 2$ .

# 37. Report on Mollusca collected at the Monte Bello Islands. By TOM IREDALE\*.

[Received March 18, 1914: Read June 9, 1914.]

(Text-figure 1.)

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The small collection brought back by Mr. P. D. Montague is still of much interest on account of the geographical position of the group.

Hedley, in the Proc. Linn. Soc. N.S.W. vol. xxviii. pp. 876–883 (1903), introduced divisional names to indicate the different faunal elements recognisable in the Marine Fauna of Australia. He determined four primary divisions, to which he gave the names Adelaidean, Peronian, Solanderian, and Dampierian Regions. The limits of the Adelaidean Region were noted as probably being Wilson's Promontory in Victoria and Geraldton in West Australia, embracing the whole southern coast of Australia and round the south-west corner. The Peronian Region designated the East Coast from Wilson's Promontory north to Moreton Bay in South Queensland. The Solanderian Region was given to the remainder of the Queensland coast northwards to Torres Straits; whilst the Dampierian Region extended westwards from Torres Straits to Houtmann's Abrolhos, scarcely north of Geraldton, West Australia.

Verco (Trans. Roy. Soc. South Austr. vol. xxxvi. pp. 202–205, 1912) has now given a list of common Geraldton and Houtmann's Abrolhos marine molluscs, which have been clearly shown to belong to the Adelaidean Region, as out of a total of 150 species, 71 per cent. were also found in South Australia. This suggests that the limit of the Adelaidean must be placed north of Houtmann's Abrolhos, and I can now show that few Adelaidean forms extend as far north as the Monte Bello Group.

Hedley recently catalogued the Queensland Marine Molluscan Fauna (Proc. Austr. Assoc. Adv. Sci. Brisbane, 1909, pp. 343–371 & 809–810), when he mentioned over 1800 species. Very numerous additions have since been made.

No list of West Australian Marine Mollusca is known to me, but it would be of great advantage to zoogeographers were such, when prepared, shown under Hedley's regional names.

\* Communicated by Prof. J. STANLEY GARDINER, M.A., F.R.S., F.Z.S.

The present collection only numbers forty-four species and it is typically Dampierian; only one Adelaidean form, *Conus anemone* Lamarck, occurring in it. The nomenclature and sequence of species here used are based upon Hedley's Queensland List above noted, the few alterations made being accompanied by notes which I submit to Mr. Hedley's consideration. For it must be acknowledged that all work on Australian molluscs has been rendered easy by the unparalleled energy displayed by Mr. Hedley, and his knowledge of the literature and forms is so complete that I know I am more likely than he to have erred.

In the British Museum there is preserved a collection made at the Monte Bello Islands and presented to that Institution by Mr. T. H. Haynes. This collection has not been determined, and includes about fifty additional species. I have not had time to investigate the nomenclature of these forms, but as far as zoogeographical relations are concerned they seem to confirm the present collection in its entirety.

In the following List I note the word Solanderian against all those included in Hedley's Queensland List:—

|   |              |
|---|--------------|
| <i>Arca fusca</i> Bruguière, 1789.            | Solanderian. |
| <i>Malleus malleus</i> Linné, 1758.           | do.          |
| <i>Ostræa cucullata</i> Born, 1778.           | do.          |
| <i>Chlamys radula</i> Linné, 1758.            | do.          |
| „ <i>squamosus</i> Gmelin, 1791, var.         |              |
| „ <i>lentiginosus</i> Reeve, 1853, var.       | do.          |
| <i>Lima lima</i> Linné, 1758.                 | do.          |
| „ <i>multicostata</i> Sowerby, 1843.          |              |
| „ <i>fragilis</i> Chemnitz.                   |              |
| <i>Modiolus philippinarum</i> Hanley, 1844.   | do.          |
| <i>Cardita incrassata</i> Sowerby, 1825.      | do.          |
| <i>Cardium dupuchense</i> Reeve, 1845.        | do.          |
| „ <i>unedo</i> Linné, 1758.                   | do.          |
| <i>Tridacna elongata</i> Lamarck, 1819.       | do.          |
| <i>Antigona tiara</i> Dillwyn, 1817.          | do.          |
| <i>Paphia literata</i> Linné, 1758.           | do.          |
| <i>Acanthopleura spinosa</i> Bruguière, 1792. | do.          |
| „ <i>gemmata</i> Blainville, 1825.            | do.          |
| <i>Haliotis squamata</i> Reeve, 1846.         | do.          |
| „ <i>varia</i> Linné, 1758, var.              | do.          |
| <i>Euchelus atratus</i> Gmelin, 1791.         | do.          |
| <i>Turbo squamosus</i> Gray, 1847.            | do.          |
| <i>Nerita albicilla</i> Linné, 1758.          | do.          |
| <i>Acmaea saccharina</i> Linné, 1758, var.    | do.          |
| <i>Cerithium fasciatum</i> Bruguière, 1792.   | do.          |
| <i>Eulima montagueana</i> , sp. n.            |              |
| <i>Subularia montebelloensis</i> , sp. n.     |              |
| <i>Cymatium aquatile</i> Reeve, 1844.         | do.          |
| <i>Natica vitellus</i> Linné, 1758.           | do.          |

|   |              |
|---|--------------|
| <i>Cypræa caputserpentis</i> Linné, 1758.                   | Solanderian. |
| „ <i>caurica</i> Linné, 1758.                               | do.          |
| „ <i>cylindrica</i> Born, 1778.                             | do.          |
| „ <i>erosa</i> Linné, 1758.                                 | do.          |
| „ <i>errones</i> Linné, 1758.                               | do.          |
| „ <i>moneta</i> Linné, 1758.                                | do.          |
| <i>Scaphella volva</i> Gmelin, 1791.                        | do.          |
| „ <i>zebra</i> Leach, 1814, var.                            | do.          |
| „ <i>hedleyi</i> , nom. nov.                                |              |
| <i>Voluta oblita</i> Smith, 1909 (= <i>norrisii</i> auct.). |              |
| <i>Ancilla elongata</i> Gray, 1847.                         | do.          |
| <i>Conus anemone</i> Lamarck, 1810.                         |              |
| <i>Arcularia suturalis</i> Lamarck, 1822.                   | do.          |
| <i>Rhodostoma auris-felis</i> Bruguière, 1789.              | do.          |
| <i>Bullaria columellaris</i> Menke, 1843.                   |              |

*Note*.—As regards generic denominations I would consider the following alterations preferable :—

|                            |           |                              |
|----------------------------|-----------|------------------------------|
| <i>Cardium unedo</i>       | should be | <i>Fragum unedo</i> .        |
| <i>Ancilla elongata</i>    | „         | <i>Amalda elongata</i> .     |
| <i>Arcularia suturalis</i> | „         | <i>Alectrion suturalis</i> . |

The species noted seem to differ sufficiently from the types of the genera first named to merit generic distinction.

*Cardita incrassata* Sowerby and *Cypræa caputserpentis* Linné occur in Verco's Geraldton List, but as both are marked as *not* occurring in South Australia, they are obviously stragglers from the north, and probably there reach their southern limit.

It will at once be observed that almost all the species occur also in the Solanderian Region, whilst it is certain that some of those not so marked do occur there, e.g. *Lima multicostata* Sowerby\*. The element characterising the Dampierian Region is not well marked in the present collection, the only notable species being the *Scaphella*, but it must again be observed that the Adelaidean element is almost completely absent, which fact is of some importance.

#### MODIOLUS PHILIPPINARUM Hanley, 1844.

Under this name I include specimens which I compared with the presumptive type specimens in the British Museum. I, however, cannot see any differences worthy of consideration between these and the type (presumably) specimens of *Modiola metcalfei* Hanley.

In the Proc. Zool. Soc. (Lond.) 1844, pp. 14–17, there is a paper entitled “Descriptions of a new species of Mytilacea &c.,” by Sylvanus Hanley. This paper was read Feb. 13, 1844, and published in July 1844. On p. 14 is described *Modiola metcalfei* from “Hab. ?, Mus. Cuming, Hanley”; and on p. 15, *M. philippinarum* from “Hab. Zebu, Philippinarum, Mus. Cuming, Hanley.”

\* I note that Hedley (Mem. Austr. Mus. iv. 1902, p. 309) regarded this as simply a variety of *Lima lima* Linné 1758, which would account for its omission from his Queensland List.

If this were the first introduction, *M. metcalfei* has priority, but in Hanley's 'Bivalve Shells,' these two species are again described and figured. The locality given for both species is the Philippine Islands, and the specimens above noted from the Cuming Collection are so labelled. Both names appear on the same page, but here again *M. metcalfei* appears first. According to the data given in the Introduction to the work this page appeared in 1843! Whichever appeared first, I conclude that *M. metcalfei* would claim usage in preference to *M. philippinarum*. If it be conceded that both species were described from the same locality, there cannot be the slightest hesitation in accepting the identity of the two species, the very slight difference in form being almost certainly due to age.

#### ANTIGONA TIARA (Dillwyn, 1817)\*.

In illegally rejecting *Cytherea* of Bolten 1798 and accepting *Antigona* Schumacher 1817 in its stead, Jukes-Browne (Proc. Malac. Soc. (Lond.) vol. xi. p. 70, 1914) has unwittingly selected the most appropriate name. For a valid reason for the rejection of *Cytherea* Bolten 1798 exists in the fact that there is a prior *Cytherea* of Fabricius, Ent. Syst. vol. iv. p. 413, 1794, as well as a *Cythere* O. F. Müller, Entomostraca, p. 63, 1785. This was unknown to Jukes-Browne and overlooked by Dall, Hedley, and Suter, who have recently used Bolten's name. According to nomenclators, *Antigona* Schumacher 1817 was predated by *Antigonus* Hübner 1816, and hence, according to British usage, invalid; but Sherborn has shown that *Antigonus* was not published by Hübner until 1820, leaving *Antigona* unassailable. This detail was also unknown to Jukes-Browne as to most malacologists.

#### ACANTHOPLEURA SPINOSA (Bruguière, 1792).

Specimens of large size were obtained, and these seem interesting on account of the southern distribution, this being the furthest south record I have traced.

#### ACANTHOPLEURA GEMMATA (Blainville, 1825).

For the past five years I have been studying the forms of the genus *Acanthopleura*, especially with relation to those grouped by Pilsbry (Man. Conch. vol. xiv. pp. 221-226, 1893) under the name *Acanthopleura spiniger* Sowerby. This would seem an appropriate place to note generally the points raised.

Hedley has accepted for the species name Linné's *Chiton aculeatus*, but I agree with Pilsbry in rejecting this as indeterminate. Pilsbry, however, discarded *Chiton gemmatus* Blainville (Dict. Sci. Nat. vol. xxxvi. p. 544, 1825) and selected *Chiton spiniger* Sowerby (Mag. Nat. Hist. 1840, p. 287, Suppl. pl. xvi. fig. 2) instead.

\* [The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature (Proc. 7th Int. Cong. Boston, 1907, p. 44 (1912)).—EDITOR.]

I can see no flaw in Blainville's description, and the locality "New Holland" suggests that it might have been brought home from Torres Straits where it was very common, or it might even have been collected by Peron and Lesueur at Shark's Bay, West Australia, whence Thiele (*Die Fauna Südwest Australiens*, vol. iii. p. 398, 1911) has recently recorded it under the name *Acanthopleura spiniger* Sowerby.

Sowerby's *Chiton spiniger* was of unknown locality, and the figure is somewhat abnormal as to the length of the spines on the girdle.

Pilsbry included *A. spiniger* Sowerby in the typical subgenus (*A. spinosa* (Bruguère) being the type of the genus) and proposed a new subgenus *Amphitomura* (Nautilus, Jan. 1893, p. 105) for *Ch. borbonicus* Deshayes, admitting *Ch. brevispinosus* Sowerby as distinct from that species but referable to the same subgenus. These two are practically from the same locality, and typical specimens prove their identity.

From the Red Sea comes a form which has just as commonly been referred to *A. "spiniger"* as to any other species, Pilsbry making note of this. I have examined many specimens, and this is undoubtedly referable to the species *brevispinosa*, but as certainly subspecifically separable. This form, which should bear Rochebrune's name *balansæ*, completely breaks down any subgeneric distinction between *brevispinosa* and *gemmata*; but the latter is just as clearly subgenerically recognisable when contrasted with *spinosa*.

Pilsbry included *Ch. echinatus* Barnes under *Acanthopleura*, though forming a subgenus (*Mesotomura*, Nautilus, Jan. 1893, p. 103) for it. I would reject this species from the genus, so that my genus *Acanthopleura* would read:—

#### ACANTHOPLEURA.

Subgenus *Acanthopleura*.

*spinosa* Bruguère.

Subgenus *Amphitomura*.

*brevispinosa* Sowerby

(=*borbonica* Desh.)

with several subspecies.

*gemmata* Blainville

(=*spiniger* Sowerby)

with several subspecies.

Subgenus *Maugeria*.

*granulata* Gmelin.

I must note that dissection of the type of *Chiton cunninghami* Reeve, described from "Australia," proves that shell to be identical with *brevispinosa* and the locality incorrect.

TURBO SQUAMOSUS Gray, 1847.

Hedley included in his List a *Turbo foliaceus* Philippi, 1846.

In the Zeitschr. für Malak. (Menke) 1846, p. 98, Philippi

described *Turbo lamellosus*. In the Conch.-Cab. (Küster) *Turbo*, p. 41, Philippi figured this species, but renamed it *Turbo foliaceus* as his former name was preoccupied by Broderip. This would seem to be the entry quoted by Hedley, the titlepage of the volume giving 1846. In the British Museum copy of this work the dates of publication have been collated, as the titlepage date referred only to the first few pages. I there find that page 41 appeared in 1847.

Gray, in the Narr. Surv. Voy. 'Fly,' vol. ii. p. 359, fig. 8, pl. ii. 1847, described the same shell from Port Essington under the name *Turbo squamosus*. There is no question of priority, however, as there is a prior *Turbo foliaceus* Gmelin (Syst. Nat. p. 3602, 1791) invalidating Philippi's name.

I have noted that Reeve (Conch. Icon. *Turbo*, fig. 17, 1848) gave the name *Turbo laminiferus* to the same species, and that specimens from Torres Straits were independently named *Turbo foliaceus* by Hombron and Jacquinot, which name was published by Rousseau in the Voy. Pôle Sud, vol. v. 1854, p. 60. The figures (Moll. pl. xiv. figs. 34-37) may have been issued earlier, but I have no data, and the invalidity of the name obviates any inquiry.

#### *ACMÆA SACCHARINA* (Linné, 1758), var.

Under the above name I have included two specimens.

In his Queensland List Hedley admitted two species of *Acmea* under the names, *Acmea costata* Sowerby 1839, and *Acmea saccharina* Linné 1758. Why the former name was used I cannot say, as in the Proc. Linn. Soc. N.S.W. 1904, p. 189, Hedley himself went into the matter of the nomenclature of the Sydney shell known as *Acmea costata* Sowerby and endeavoured to prove that name inapplicable, and that the correct name was *Acmea alticostata* Angus (Proc. Zool. Soc. (Lond.) 1865, p. 56, pl. ii. fig. 1) given to a South Australian form. I have not seen any controversion of Hedley's argument, so with the help of Mr. G. C. Robson, of the British Museum, I tried to clear the matter up. Working at this group Mr. Robson recovered the specimen from which the figure of *Lottia? costata* Sowerby (Zool. Beechey's Voy. 1839, p. 147, pl. xxxix. fig. 1) was prepared, and it proves to have the data "Arica, Peru" on the back of the tablet. It is obviously not the Australian shell, and this discovery absolutely disposes of Sowerby's name as referable to the Sydney *Acmea*.

The same species occurs in South Queensland, but in North Queensland it is replaced by a different species, which Hedley catalogued as *Acmea saccharina* Linné 1758. At Port Curtis I collected a series of specimens, and the determination of the name to be used has caused quite a lot of trouble.

Mr. Robson has investigated the question of the type locality of Linné's *Acmea saccharina* and has fixed this as the Philippine

Islands. This is necessary, as there can be no question that, due to the wide range of the species, it can and must be divided into subspecies. In the latest Monograph of the family, Pilsbry (Man. Conch. vol. xiii. p. 49 *et seq.*, 1891) did not determine these but admitted *Acmaea saccharina* Linné, quoting as a synonym *Patella lanx* Reeve: p. 50, var. *stellaris* Q. & G., giving as synonyms *stella* Lesson and *octoradiata* Hutton, and naming p. 50, var. *perplexa* nov., from Australia, quoting under this name *stellaris* Reeve and *octoradiata* Hutton. He accepted Sowerby's name *costata* for the Australian shell, synonymising with it Angas's *alticostata*. In the Proc. Linn. Soc. N.S.W. 1904, p. 188, Hedley put on record that Pilsbry's var. *perplexa* was absolutely Hutton's *octoradiata*, and that this was a valid species. There can be no question about this, but Hedley accepted Hutton's name, whereas he should have chosen Pilsbry's, as Hutton's name was invalidated by *Patella octoradiata* Gmelin, Syst. Nat. p. 3699, 1791.

Suter, reviewing New Zealand Acmaeidae (Proc. Malac. Soc. (Lond.) vol. vii. pp. 315-326, 1907), recognised in *Patella stella* Lesson (Voy. 'Coquille,' vol. ii. p. 421, 1831) the shell commonly known as *corticata* Hutton, but admitted the form Hutton named, with subspecific rank. He also pointed out its alliance with the Australian *A. alticostata* Angas. The New Zealand species is certainly specifically distinct from every form of *saccharina*.

At the same place Suter admitted *octoradiata* Hutton, and placed these two species in a subgenus *Collisellina*. This name was proposed by Dall (Amer. Journ. Conch. vol. vi. p. 259, 1871) for his section B, which covered *saccharina* Linné and *borneensis* Reeve. In the Voy. de l'Astrol., Zool. vol. iii. pt. ii. p. 349, 1835, Quoy and Gaimard introduced their genus *Patelloïda* for southern Limpet-like forms with distinct anatomical features. In 1847 Gray designated as type *P. rugosa* Q. & G., and as this is one of the original members of the genus this selection must stand. I suggest that *P. rugosa* Q. & G. is a member of the present group, and that *Patelloïda* Quoy and Gaimard should displace *Collisellina* Dall. The group is well defined and easily recognisable.

*Patelloïda stellaris* Q. & G. for a New Ireland shell, which is certainly not identical with the North Australian form, is invalid on account of Bolten's *Patella stellaris* (Mus. Bolten. p. 12, 1798) given to a different form of *A. saccharina*.

*Patella lanx* Reeve was described from Japan.

Other early names given to *saccharina*-like shells are all inapplicable to the Australian form, which is therefore unnamed. These differ appreciably from typical specimens, whether specimens from Monte Bello Islands, Port Essington, Cape York, or Port Curtis are contrasted, and I therefore note them as *A. saccharina* Linné, var.

Verco referred the shells from South-West Australia to *A. alticostata*, and specimens in the British Museum labelled West

Australia and Swan River, West Australia, confirm this disposition, as they closely approach the South-East Australian species and are very different from any form of *Acmea saccharina*.

These sketchy remarks must well show the confusion that exists in this family, and the urgent need of a skilful and careful monographer.

My notes would read easily if summarised thus:—*Acmea saccharina* Linné. Type locality, Philippine Islands, divisible into subspecies: *Patella lanx* Reeve, Japan, one valid name. *Patelloida stellaris* Quoy & Gaimard, New Ireland: form probably recognisable, name invalid. Subspecies ranging from Cape York westwards to Monte Bello Islands and southwards to Port Curtis, recognisable but unnamed.

*Acmea saccharina*, var. *perplexa* Pilsbry is a distinct species, commonly called *Acmea octoradiata* Hutton, but Hutton's name is invalid.

*Acmea alticostata* Angas is the name for the Sydney shell, which ranges southwards through Bass Straits and then westwards to Geraldton, West Australia, and this is quite a valid species. Sowerby's *Lottia? costata* (type preserved in the British Museum) came from Arica, Peru, and has no connection with the Australian shell erroneously so-called.

*Acmea stella* Lesson, from New Zealand, is closely allied to *A. alticostata* Angas, but is certainly separable as a distinct species.

The group is well marked and has been classed under *Collisellina* Dall 1871, but Quoy and Gaimard's genus name *Patelloida* seems to claim usage on account of Gray's designation of *P. rugosa* Q. & G. as type. I regard this species as certainly referable to this group.

#### EULIMA MONTAGUEANA, sp. n. (Text-fig. 1 A, B.)

Shell of medium size for the genus, thin, smooth, solid, glassy, imperforate, not translucent, variced, many-whorled, sutures impressed. Colour milk-white. In shape it is sharply conical with the spire somewhat tending backwards. The largest specimen has the apex missing, but fourteen whorls remain. The next in size, which I select as the type, has the apical whorl somewhat bulbous and succeeded by fifteen whorls, the basal three or four whorls showing a peripheral keel. Varices regularly succeeding and advancing spirally can be observed on the last ten whorls; on the spire whorls these are too indistinct for recognition.

Aperture obliquely pyriform, outer lip simple but not thin, base somewhat contracted; columella straight and reflected as a slight callus which extends across the body-whorl to join the outer lip at the posterior angle.

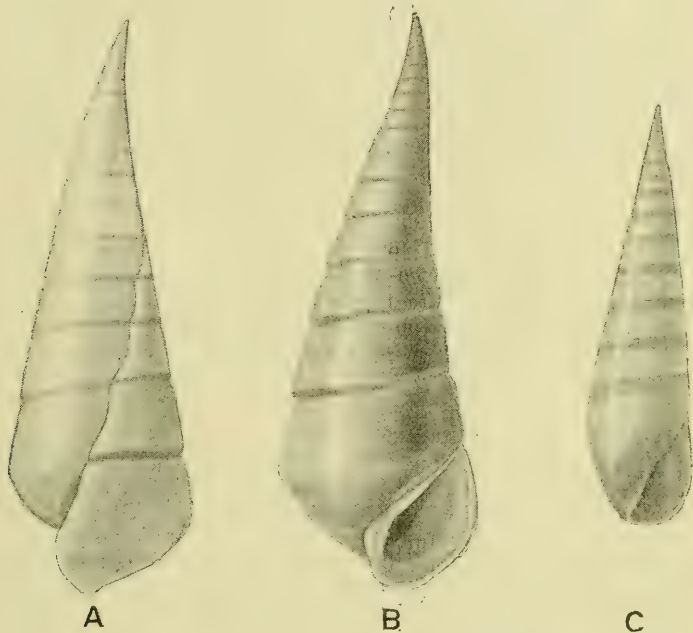
Length of type 17.5 mm., breadth 5.5 mm.

*Habitat.* Off Hermite Island, Monte Bello Group. Dredged in 4 fathoms

*Remarks.* *Melanella* Bowdich 1822 has been shown to have priority over *Eulima* Risso 1826; but as the type of the former is a "humpbacked" species it has been suggested that these might be separated generically, and *Eulima* might be retained with the conventional usage.

I have not yet examined the type of *Melanella*, but Australasian "humpbacks" seem to have apical features very distinct from species of *Eulima* occurring with them.

Text-figure 1.



A. Side view of *Eulima montagueana* showing lateral ascending varices.

B. Front view of *Eulima montagueana*.

C. *Subularia montebelloensis*.

*SUBULARIA MONTEBELLOENSIS*, sp. n. (Text-figure 1 C.)

Shell small, thin, not translucent, slender, aciculate, imperforate, glossy, white, many-whorled, smooth. Apex very slender, the apical whorl minute with sixteen succeeding whorls, the sutures indistinct but followed by a transparent band, the remainder of the whorl milky.

The last whorl has the periphery rounded and varices do not appear to be present. The aperture is oval, anteriorly broadened and subchannelled; columella truncate, advancing obliquely and slightly reflected as a callus extending across the body-whorl.

Length of type 12.5 mm., breadth 3 mm.

*Habitat.* Off Hermite Island, Monte Bello Group. Dredged in 4 fathoms.

*Remarks.* A vague resemblance to *Eulima acicula* Gould may account for the previous non-recognition of this species. Tryon (Man. Conch. vol. viii. 1886) synonymised with that species, *aciculata* Sowb., *pyramidalis* Sowb., and *vitrea* A. Ad., an incongruous combination needing no criticism, but since that time little work appears to have been done on this group as regards Indo-Pacific species.

Tryon placed these in *Eulima* in the section *Subularia* Monterosato, which name was proposed to replace *Leiostraca* Adams, which was considered preoccupied. As there is a prior *Leiostracus* as well as *Liostraca* and *Liostracus*, I would agree in rejecting *Leiostraca*.

This species is not a typical *Subularia*, but might be referable to Monterosato's section *Acicularia*, but that name is preoccupied.

#### NATICA VITELLUS (Linné, 1758).

I had determined the Monte Bello shell as *Nerita rufa* Born, and noted its absence from Hedley's Queensland List, before I received my friend's latest paper (Proc. Linn. Soc. N.S.W. vol. xxxviii. 1913), where on p. 299 he recorded this species from Palm Island, Queensland, and noted that the correct name for the species was as given above.

#### SCAPHELLA ZEBRA Leach, 1814, var.

The shells do not agree with typical *S. zebra*, from the East Coast of Australia. In the British Museum, similar shells from West Australia were named *S. ellioti* Sowerby. Upon investigation this name was found to have been given to a North Australian shell (Journ. de Conch. 3rd ser. vol. iv. p. 338, 1864; vol. v. p. 25, pl. iii. fig. 19, 1865), and the figure did not agree with West Australian examples. As far as I can trace, no name has yet been given to the West Australian shell. I, however, forbear its nomination, and in preference record it as above: it cannot be called *S. turneri*, as the figure of *Voluta turneri* Griffith and Pidgeon (Anim. Kingdom Cuv. vol. xii. Moll. pl. xl. fig. 1, Index, p. 601, 1834: no locality given) shows quite a different shell.

#### SCAPHELLA HEDLEYI, nom. nov.

*Scaphella reticulata* (Reeve) does not appear in Hedley's Queensland List, but was added to that fauna by Shirley (Proc. Roy. Soc. Queensland, vol. xxiii. p. 99, 1911) from the Gulf of Carpentaria.

The species was described by Reeve in the Proc. Zool. Soc. (Lond.) 1843, p. 144, under the name *Voluta reticulata*, and figured in the Conch. Icon., *Voluta*, sp. 25, pl. xi. figs. 25, a-b.

That name, however, had been previously utilised by Linné (Syst. Nat. 12th ed. p. 1190, 1767) and Martyn (Univ. Conch. vol. iv. fig. 126, 1787), and as I have noted no synonymy I propose to rename Reeve's species as above. It gives me great pleasure to associate with such a beautiful shell the name of my friend Mr. C. Hedley. Sowerby's *V. gatliffi*, described from North Australia, differs in shape as well as coloration, and I know no other species that can be compared with this.

*CONUS ANEMONE* Lamarck, 1810.

In his latest paper cited above Hedley (p. 307) gave some notes on this species, observing that the West Australian shell seemed to be typical and noted it from Port Essington and also Tasmania. My specimens from Monte Bello Islands agree with his conclusions, so I anticipate that Verco's Geraldton record would also agree. If it be conceded that the East Australian shells are only sub-specifically distinct (my own shells from Sydney, New South Wales, and Lord Howe Island agree with Hedley's remarks) then the names to be used would be

*Conus anemone* Lamarck. North, West, and South Australia ;  
of which *C. novæhollandiæ* A. Adams is an absolute synonym ;  
and

*Conus maculosus* Sowerby. East Australia and Lord Howe  
Island ;

with *jukesii* Reeve, *maculatus* Sowerby, and *rossiteri* Brazier, as  
absolute synonyms.

*RHODOSTOMA AURIS-FELIS* (Bruguière, 1789).

The genus name here used was introduced by Swainson, Treat. Malac. pp. 208, 344, 1840, the species cited being *coffea* Chemn. 120, f. 1043 ; *fabula* Fér. Tab. Syst. 105, n. 24 ; and *nucleus* id. ib. n. 26. In the Tab. Syst. Moll. Férussac, p. 109 (or 105) included *fabula* in *Auricula* (*Conovulus*), and then proposed *Auricula* (*Cassidula*) *felis* Lamarck=*coffea* Chemn., and added *Auricula nucleus* without any subgeneric designation. *Cassidula* has been used for the group typified by *auris-felis* Bruguière (= *coffea* Chemn.) ever since this introduction, which only dates from 1821. In the Syst. Anim. p. 348, 1801, twenty years previously, Lamarck had proposed *Cassidulus* for an Echinid, which name is now generally accepted as invalidating *Cassidula*.



## 38. Cephalopoda from the Monte Bello Islands.

By G. C. ROBSON, B.A.\*

[Received March 18, 1914: Read June 9, 1914.]

(Text-figure 1.)

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Of the two species of Cephalopoda obtained by Mr. P. D. Montague from the Monte Bello Islands, one specimen is of considerable interest—a Myopsid which has been referred after some hesitation to *Sepiadarium*.

The differences between the latter genus and the closely-allied *Sepioloidea*, though they have been touched upon by several authors, have not been fully summarized as yet. The following table gives the more important differences:—

*Sepiadarium* Steenstrup.*Sepioloidea* d'Orb.

- |  |  |
|--|--|
| 1. Funnel attached to mantle by a ligament (1) (2).  | ... by cartilaginous plugs of the mantle that fit into sockets on the funnel (1) (2).                      |
| 2. Ventral pores absent (2).   | ... present (2).   |
| 3. Mantle fringe absent (2).   | ... present (2).   |
| 4. Fins short (4).   | ... long (4).  |
| 5. The hectocotylized arm bearing on its distal half a series of transverse ridges, which are the laterally produced peduncles of the suckers (4). | Suckers of the hectocotylus persisting as small papillæ; the arm grooved diagonally on its inner side (4). |

In respect of Nos. 1, 2, 3, and 5 in the above list, the form here described is referable to *Sepiadarium*. The length of the fins, on the other hand, suggests affinity with *Sepioloidea*. It is not desirable on such slender grounds, however, to create a new genus intermediate between the two forms under discussion for the reception of this species. But it is certain that in the present state of our knowledge we are entitled to regard this as an unusual form of *Sepiadarium*, intermediate in respect of one character between that genus and *Sepioloidea*.

\* Communicated by Prof. J. STANLEY GARDINER, M.A., F.R.S., F.Z.S., and published by permission of the Trustees of the British Museum.

Up to the present *Sepioloidea* appears to be regarded as the Australian form of the two Sepiadarian genera, while *Sepiadarium* is considered the Pacific form. We now find that the latter extends its range to W. Australia, though not by a typical member of the genus. Whether, in the first instance, the distinction of the two forms into Pacific and Australian rested upon secure and sufficient evidence we cannot say as yet. If the investigation of the Cephalopod faunas of these areas upholds this distinction, the interest and importance of this species of *Sepiadarium* with *Sepioloidea*-characters, as occurring in the distributional area of the other genus, will be increased.

The structure of the hectocotylus corresponds closely with that described by Brock (5) for *Sepiadarium*. It should be observed that the series of transverse ridges or bars (Brock's "Quer-balken") are of such a shape as to suggest the obvious conclusion that they represent the fused bases of the pairs of suckers, a proximal member of the morphologically posterior row being fused with a distal member of the morphologically anterior row.

#### 1. SEPIADARIUM AURITUM, sp. n. (Text-fig. 1.)

*External appearance.*—The animal is small and squat, the width of the mantle area being about equal to its length. The fins are rather long and ear-shaped, the inferior portion being slightly broader than the superior. The mantle-insertion at the neck is tolerably broad, while posteriorly the edge of the mantle exhibits a very slight concavity.

There is a very feebly developed interbrachial membrane. On the arms the suckers are arranged in two alternating rows, save at the distal third, where they become abruptly smaller and more irregularly disposed.

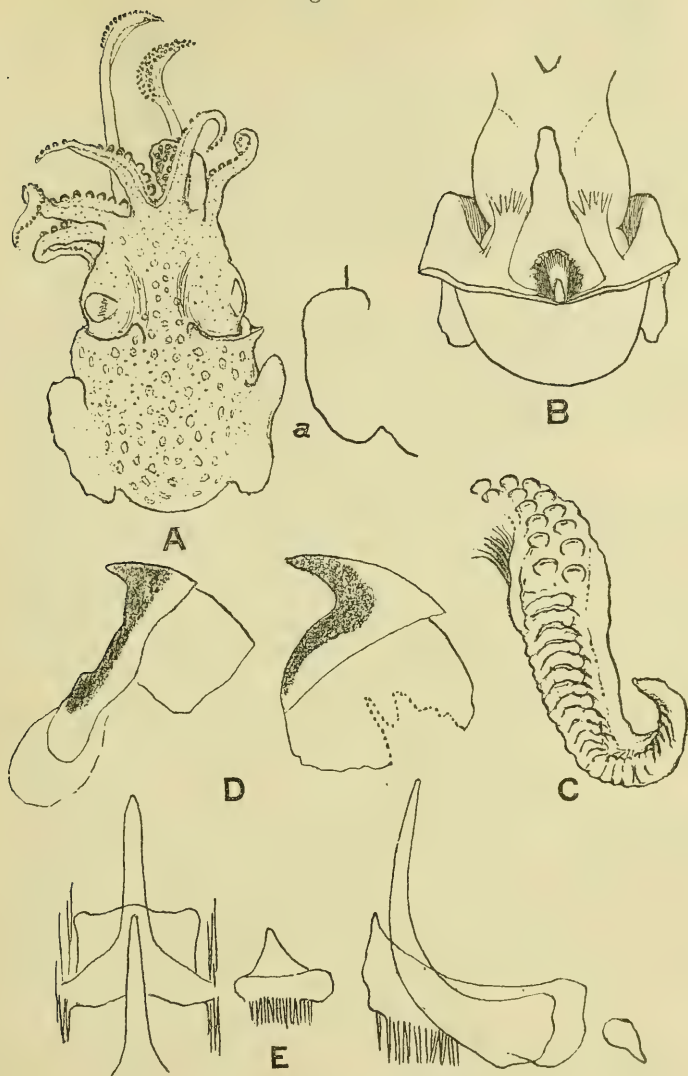
The tentacular arms are provided with a short membrane continuous with the area occupied by the suckers.

The colour (formalin-preserved specimen) is dull grey, covered on the dorsal surface by numerous small round patches of pale red or brown and fine black or dark-brown spots. Only the latter are continued on to the ventral surface and the arms. The patches and spots are found, though more sparsely, upon the fins. For character of the hectocotylized arm, v. text-fig. 1, C.

#### *Dimensions:*—

|  |           |
|--|-----------|
| Mantle, max. length .....  | 11.25 mm. |
| „ max. breadth .....   | 12.5 „    |
| Length of fins .....   | 8.75 „    |
| Total length (from apex of mantle<br>to interbrachial membrane of<br>the ventral arms) ..... | 17.5 „    |
| Length of arms: 1st pair .....   | 7 „       |
| 2nd „ .....  | 6.8 „     |
| 3rd „ .....  | 9 „       |
| 4th „ .....  | 7 „       |

Text-figure 1.

*Sepiadarium auritum.*

- A. Dorsal view.  $\times 2$ :  $\alpha$ , outline of fin.  
 B. Attachment of funnel to mantle.  $\times 2$ .  
 C. Hectocotylus.  $\times 6$ .  
 D. Mandibles.  $\times 12$ .  
 E. Radula. 4 oc.  $\times 6$  obj.

*Internal characters.*—The *mandibles* (text-fig. 1, D).

The *radula* (text-fig. 1, E) resembles that of *S. kochii* figured by Appellöf (3) pretty closely ; but differs in the condition of the basal plate of the median tooth, which is much deeper and of a different shape, in certain characters of the lateral tooth and of the inferior marginal. It is unfortunately impossible to give a fuller account of the internal characters, owing to the fact that only one specimen is available for examination.

*Locality.* Dredged off Hermite I. (Monte Bello Islands), W. Australia.

Type in the British Museum (Zoological Department).

## 2. POLYPUS sp.

Two specimens from the same station (one immature).

This form, which might be referable to more than one Pacific species, cannot be satisfactorily identified.

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3. APPELLÖF, A. Abh. Senckenb. Naturf. Ges., Bd. xxiv. 1898, p. 561.
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## 39. Description of a new Lizard from the Canary Islands \*.

By Dr. PH. LEHRS †.

[Received May 14, 1914; Read May 19, 1914.]

LACERTA CÆSARIS.

Abstract P. Z. S. 1914, p. 41 (May 26th).

*Physiognomy and general proportions* of *Lacerta galloti*, but much smaller and, from a phyletic point of view, of a more primitive pattern of coloration.

*Head* rather large, difference in size according to sexes not so marked as in *L. galloti* and its larger allies. Length of head  $\frac{1}{4}$  of length to vent in the male, very little less in the female. The cheeks not noticeably swollen in the male. Width of head  $\frac{1}{3}$  of the length, depth  $\frac{1}{2}$ , width of pileus  $\frac{1}{2}$  in both sexes. Snout as long as the postocular part of head (to posterior border of tympanum) in the female, slightly longer in the male.

*Neck* distinctly narrowed. *Body* slightly flattened.

*Tail* long, more than two-thirds total length.

*Limbs* elongate, the fore limb in both sexes reaching the nostril, the hind limb reaching the collar or not quite so far in the female, a little beyond in the male.

*Rostral* usually touching the nostril ‡, separated from the frontonasal.

*Frontonasal* as long as broad or slightly longer.

*Frontal* a little shorter than its distance from the end of the snout in the female, but slightly in the male; twice as long as broad (on its narrowest point) in the female, slightly longer in the male; not touching the first supraocular.

*Supraoculars* separated from superciliaries by a series of granules.

*Parietals* as long as, or slightly longer, rarely shorter § than the frontal in the male, usually a little longer in the female, strongly bent down on the temple, occupying the place usually held by the supratemporals ||.

*Occipital* at least as broad as the interparietal, usually considerably broader, and constantly broader than long; on an average larger in the male than in the female ¶.

A single *postnasal*. 5 *upper labials* anterior to the subocular \*\*.

\* [The complete account of the new species described in this communication appears here, but since the name and a preliminary diagnosis were published in the 'Abstract,' No. 134, 1914, the species is distinguished by being underlined.—

EDITOR.]

† Communicated by Dr. G. A. BOULENGER, F.R.S., F.Z.S.

‡ Exceptions rare: for instance in Nos. 3 and 14 of the annexed table.

§ For instance in No. 13.

|| The author does not wish to support the theory of a fusion of the said shields.

¶ As is generally the rule in the species of *Lacerta*.

\*\* Two superposed anterior loreals on each side in No. 4, double anterior suboculars in No. 12.

|                 | Total length. | From end of snout to vent. | Tail. | From end of snout to fore limb. | Length of head. | Width of head. | Depth of head. | Width of pileus. | Fore limb. | Hind limb. | Dorsal scales across middle of body. | Longitudinal series of ventral plates. | Transverse series of ventral plates. | Width and length of frontal shield. | Width and length of interparietal shield. | Width and length of occipital shield. | Gular scales. | Collar plates. | Femoral pores (right/left). | Subdigital lamellæ. |
|-----------------|---------------|----------------------------|-------|---------------------------------|-----------------|----------------|----------------|------------------|------------|------------|--------------------------------------|--|--------------------------------------|-------------------------------------|---|---------------------------------------|---------------|----------------|-----------------------------|---------------------|
| 1. ♂ ... (143)  | 74            | (69)                       | 30    | 18.5                            | 12              | 9              | 9              | 28               | 45         | 90         | 10-12                                | 30                                     | 3.5 ; 5.5                            | 1.75; 2                             | 3 ; 2.25                                  | 40                                    | 7             | 29, 30         | —                           |                     |
| 2. ♀ ... (154)  | 77            | (77)                       | 28    | 18                              | 12              | 8.5            | 8.5            | 27               | 41         | 96         | 10-12                                | 31                                     | 3.5 ; 5.25                           | 1.75; 2.25                          | 2.5 ; 2                                   | 38                                    | 9             | 29, 28         | 33                          |                     |
| 3. ♂ ... (206)  | 72            | (134)                      | 28    | 18                              | 12              | 9              | 9              | 26               | 42         | 102        | 12                                   | 30                                     | 3.5 ; 5.25                           | 1.75; 1.75                          | 2.75; 2                                   | 44                                    | 11            | 29             | 32                          |                     |
| 4. ♀ ... (156)  | 72            | (84)                       | 27    | 17                              | 11              | 8.5            | 8.5            | 25               | 40         | 100        | 10                                   | 30                                     | 3 ; 5                                | 1.75; 1.75                          | 2 ; 1.75                                  | 40                                    | 11            | 29, 28         | 33                          |                     |
| 5. ♂ ... (165)  | 72            | (93)                       | 29    | 18                              | 12              | 8.5            | 8.5            | 27               | 43         | 105        | 12                                   | 30                                     | 3.25; 5.25                           | 1.75; 1.75                          | 3 ; 2.25                                  | 43                                    | 9             | 27, 26         | 35                          |                     |
| 6. ♀ ... (188)  | 70            | (118)                      | 26    | 16                              | 10.5            | 8              | 8              | 24               | 38         | 99         | 10                                   | 30                                     | 3 ; 4.75                             | 1.5 ; 1.5*                          | 1.75; 1.75                                | 33                                    | 7             | 25, 24         | 33                          |                     |
| 7. ♂ ... (164)  | 68            | (96)                       | 27    | 17.5                            | 11.5            | 8              | 8              | 26               | 42         | 98         | 10-12                                | 30                                     | 3.25; 5.25                           | 1.5 ; 1.75                          | 2.75; 2                                   | 39                                    | 7             | 31, 30         | 30                          |                     |
| 8. ♀ ... (206)  | 66            | (140)                      | 26    | 16.5                            | 10.5            | 8              | 8              | 23               | 37         | 91         | 12                                   | 30                                     | 3 ; 5                                | 1.75; 2†                            | 2.75; 1.75                                | 36                                    | 8             | 26             | 33                          |                     |
| 9. ♀ ... 218    | 66            | 152                        | 25    | 16                              | 10              | 7.5            | 7.5            | 23               | 36         | 95         | 12                                   | 30                                     | 3 ; 4.5                              | 1.5 ; 1.75                          | 2.5 ; 1.75                                | 38                                    | 10            | 25             | 31                          |                     |
| 10. ♀ ... 204   | 59            | 145                        | 24    | 14                              | 9               | 6              | 6.5            | 22               | 36         | 95         | 10                                   | 31                                     | 2.75; 4.25                           | 1.5 ; 1.75                          | 2 ; 1.5                                   | 43                                    | 11            | 28, 26         | 34                          |                     |
| 11. ♂ ... (110) | 56            | (54)                       | 24    | 14.5                            | 9.5             | 7              | 7              | 22               | 35         | 110        | 10+2                                 | 29                                     | 2.75; 4.5                            | 1.5 ; 1.75                          | 1.75; 1.25                                | 42                                    | 9             | 28             | 36                          |                     |
| 12. ♀ ... 180   | 54            | 126                        | 22    | 13.5                            | 8.5             | 6.5            | 6.5            | 20               | 33         | 94         | 10+2                                 | 30                                     | 2.5 ; 4.25                           | 1.5 ; 1.75                          | 2 ; 1.5                                   | 41                                    | 10            | 27             | 32                          |                     |
| 13. ♂ ... (160) | 54            | (106)                      | 23    | 14.5                            | 9.5             | 7              | 7              | 21               | 34         | 98         | 12                                   | 29                                     | 2.75; 5                              | 1.5 ; 2                             | 2.5 ; 1.5                                 | 43                                    | 8             | 28, 27         | 33                          |                     |
| 14. ♀ ... 176   | 53            | 123                        | 22    | 13.5                            | 8.5             | 6.5            | 6.5            | 20               | 33         | 91         | 12                                   | 31                                     | 2.25; 4.25                           | 1.5 ; 1.75                          | 2 ; 1.25                                  | 39                                    | 9             | 28, 29         | 33                          |                     |

\* Scutum intercalare 0.75; 0.5.

† Scutum intercalare 0.5; 0.25.

*Temporal scutellation* granular, often finely, with more or less developed masseteric and tympanic shields; a series of small supratemporals.

*Scales covering the lower eyelid* extremely small and granular, those in the centre scarcely, if at all, differentiated.

*Dorsal scales* very small, rhombic-granular, more or less distinctly keeled, 90–110 across the middle of the body; 3 or 4 series corresponding to one ventral plate.

*Upper caudal scales* much smaller than the dorsals.

*Gular scales* 33–44 on a line between the collar and the third pair of chin-shields; gular fold distinct, collar not serrated, composed of 7–11 plates.

*Ventrals* in 10 or 12 longitudinal and 29–31 transverse series.

*Anal* comparatively small.

*Femoral pores* 24–31.

*Subdigital lamellæ* 30–36 under the fourth toe.

*Coloration* (from life). Pileus of a dark or light bronze-brown, more or less profusely speckled with black.

Superciliary streak, if distinct, on each side running entirely upon the parietal and continued to the base of the tail, or beyond; this streak of a bright yellow in life.

A light streak along the spine, well defined from the bronze colour of the dorsal region.

A short subocular streak, of a duller yellow than the superciliary, and often interrupted, extends a little way beyond the tympanum in the middle of the dark brown temporal band, which is edged below by a continuous dull yellow streak, extending from below the tympanum to the base of the hind limb, reappearing again on the side of the tail.

The dark bands in some specimens (young males) with small light, dark-edged spots without any tendency to form transverse series. Larger bright spots on the limbs.

Lower surface of head blackish grey, or even black in full-grown specimens; the dark shade sometimes extending to the breast. Belly dirty white, or pale greyish, without any spots; a few roundish, bluish-white spots sometimes present on the margin.

Frequently a small sky-blue spot on the dark temporal band above the insertion of the fore limb, another of the same colour on the upper arm. In a few adult females the whole lower surfaces of the thighs of the same bright blue.

In some fully adult males the markings become very indistinct or may nearly entirely vanish, such specimens being blackish brown.

Iris silvery.

*Habitat*: Hierro, Canary Islands; a large number of specimens were collected by Dr. Caesar Boettger at Las Lapas, in the "Golfo" of Hierro, and presented to me in August, 1913.

The types, which I received alive, are preserved in my private collection.

This species belongs to the same group as the well known  
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*L. galloti* D. B., from which it differs to the same extent as *L. simonyi* Steind., from the "Roques del Zalmore," near Hierro, but in an opposite direction.

It differs from *L. galloti* in its smaller size, in its broader occipital shield, in the downward extension of the parietal shields, in fewer longitudinal rows of ventral shields (10-12, instead of 12-14), in the higher number of dorsal scales (90-110, instead of 80-98), in the more primitive pattern of coloration, as well as in the feeble degree of secondary sexual differentiation.

In my opinion it represents the most primitive type of the *L. galloti* group.

40. The Mechanism of Suction in the Potato Capsid Bug, *Lygus pabulinus* Linn. By P. R. AWATI, B.A. (Cantab.), D.I.C. (Lond.), Sir John Wolfe-Barry Research Scholar, Imperial College of Science, London\*.

[Received January 31, 1914: Read March 17, 1914.]

(Text-figures 1-29.)

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### INTRODUCTION.

The investigation of the mechanism of suction in *Lygus pabulinus* arose out of an inquiry by Professor Lefroy, of the Imperial College of Science, and Mr. Horne into the production by insects, on the foliage of the potato, of symptoms resembling those produced by fungi and by bacteria. They had produced definite symptoms by the infection of potato foliage with a Capsid (*Lygus*), a Jassid (*Eupteryx*), and other sucking insects; the symptoms were markedly characteristic of the different species; and the investigation of the actual mechanism of suction thus became necessary. I took up this inquiry at the suggestion of Professor Lefroy, who was in India at the time.

The insect is common on the potato and other plants during the summer. More than one species of *Lygus* is concerned with the damage to the plants. The species used in this investigation has been identified by Mr. W. L. Distant at the Natural History Museum as *Lygus pabulinus* Linn.

The scope of this paper is limited. It does not pretend to give full anatomical or morphological descriptions, but it describes the different structures of the head, both morphologically and anatomically, as far as they appear to be important in the mechanism of suction.

I very gratefully acknowledge my indebtedness to Prof. Lefroy for his help and encouragement during the whole of my work, to Mr. Clifford Dobell for his valuable criticism and suggestions, and to Mr. H. G. Newth for his assistance in preparing the paper for press.

\* Communicated by Prof. H. MAXWELL LEFROY, M.A., F.Z.S.

## MATERIAL AND METHOD.

I began my work in the Chelsea Physic Gardens of the Imperial College of Science, but, since the specimens were scarce, I had to go to Wisley, where I got good material through the kindness of Mr. F. Chittenden, the Director of the Wisley Horticultural Laboratory.

The following reagents were used for fixing the insects :—

- (i.) Bouin's solution,
- (ii.) Carnoy solution (Formula No. II),
- (iii.) Petrunkevitch solution ;

and all of these have given satisfactory results.

The insects were kept in the fixing reagent for 24 hours, and, without being passed through the lower grades of alcohol, were thrown into 90 per cent. alcohol, in which they were allowed to remain for several weeks. Thus treated, they were sufficiently hardened for section-cutting, and it was, therefore, not necessary to keep them in absolute alcohol for more than three hours. After immersion for one hour in a mixture of equal parts of absolute alcohol and chloroform, they were transferred to pure chloroform, in which they were left for 24 to 36 hours. They were now imbedded in paraffin-wax (melting-point  $56^{\circ}$  C.) in the following way:—A saturated chloroform solution (in the cold) of wax of the same melting-point was prepared and the specimens were allowed to lie in it for two or three days at the temperature of the laboratory. They were then transferred to pure molten wax in the oven, where they remained for five hours. A block was then prepared in the usual way.

The importance of attention to the details of the above routine cannot be overrated. There is in the literature, so far as I can find, no single detailed description of a method by which good sections of hard insects can be got, and it is notoriously difficult to find any but diagrammatic illustrations to the papers of those who have investigated such forms. As the result, however, of my experiments, I have found that it is possible to obtain series of excellent sections, not only of *Lygus*, but of such hard and thickly-chitinated insects as the bed-bug, without using any reagent for softening the chitin. I am therefore justified in giving some prominence to the technique.

Long soaking in a mixture of chloroform and wax was found to be the only way to obtain proper impregnation, and the time given is the optimum—a shorter time is insufficient, a longer causes the tissues to become brittle. The length of the soaking differs with different insects, according to the quality of their chitin.

The sections were stained, in the ordinary way, with Ehrlich hæmatoxylin, orange G, and picric acid (saturated solution in 90 per cent. alcohol).

For macerating purposes, potash (10 per cent.) was used. A few drops of acetic acid were found useful. The specimens were

generally cleared in turpeneol, which did not make them brittle, even if they were kept in it for a long time.

#### HOMOLOGIES OF THE MOUTH-PARTS OF RHYNCHOTA.

The problem of the true homologies is very difficult, and has only recently been solved. In this section I propose to give a summary of the literature dealing with this problem.

Fabricius gave the name "Rhynchota" to the insects comprised in the class "Hemiptera," on account of their sucking mouth-parts. But till the time of Savigny (42), no attempt was made to homologue their mouth-parts with those of other (biting) insects. He hit upon the interpretation which is now generally accepted. According to him, the mouth-parts of the Rhynchota are homologous with those of the biting insects; the maxillæ, the mandibles, and the labium being represented in these forms by the internal stylets, the external stylets, and the proboscis, respectively. His interpretation has been endorsed by Kirby and Spence, Burmeister, and lately by Heymons and Leon.

Savigny and Cuvier, one with *Nepa cinerea*, and the other with *Ranatra linearis*, had found the labial palps articulated to the proboscis. But they could not discover any trace of the maxillary palps, which are well-developed structures in the biting insects. They had not, therefore, good evidence for the homologies of the maxillæ.

These matters will be better elucidated if the history of the homologies of each part be treated separately.

#### *The Proboscis, or Schnabelscheide.*

There were two views with regard to the structure of the proboscis before 1880 :—

(i.) Burmeister (5), Latreille, and Graber held that the proboscis was formed by the second maxillæ fusing together with the labial palps. Burmeister has stated this view in very general and vague terms, but it was Kraepelin (25, 26) who elaborated it in detail. According to him the first segment of the proboscis corresponds to the submentum and mentum together, and the three segments, 2, 3, 4, to the three segments of the labial palps of the biting insects. This view had been supported by the fact that there were, on the second joint of the proboscis, certain strong chitinous tubercles which were supposed by him to be the rudiments of the organs, *i. e.* extremities of external and internal lobes of the palps. Leon (30), however, takes them to be the chitinous supports for the muscles of the proboscis, running into the head.

This view has been exploded, and no present-day writers think seriously of it, its interest being now purely historical.

(ii.) The second view was first formulated by Savigny and Cuvier, and is now generally accepted. Savigny, in *Nepa cinerea*, and Cuvier, in *Ranatra linearis*, discovered certain jointed

structures articulated to the proboscis, which they took to be the labial palps. The palps are, therefore, in this view, separate from the proboscis, and do not take any part in its formation, the proboscis being formed by the fusion of the second maxillæ only.

After Savigny comes Gerstfeldt (14). He elaborated this view as Kraepelin had done the earlier one. According to him :

“Das erste Glied das nach Burmeister allein die Unterlippe darstellt, wäre an das submentum und entspräche den Cardines der Lippenkiefer, das zweite Glied bestände aus den beiden Stipites und wäre analog dem Mentum, das dritte und vierte Glieder gehörten zusammen den Endlappen der Unterlippe an und entsprächen entweder nur den äusseren Laden (Paraglossæ) oder nur den unteren Laden (Ligulæ), oder aber, was mir noch wahrscheinlicher ist, beiden mit einander vereinigten Ladenpaaren zugleich.”

Leon (29-33) has fully dealt with the question of the homologies of the proboscis. His examples are taken from the Belostomidæ. He clearly demonstrated the presence of the labial palps as distinct from the proboscis, and came to the following conclusion, after examining all the examples :

“Es ist ganz gleichgültig, in welcher Weise die Glieder der Scheide von einer Art zur andern, sei es als Form, Grosse, als Borstenanzahl, als Chitinerhebungen, etc. variieren möchten, eins bleibt immer constant, das die Scheide aus derselben Zahl von Gliedern besteht, die immer dieselbe Stellung zu einander haben und die vollkommen homolog sind den Bildungsgliedern des Labiums der beissenden Insecten.”

In the meantime, Dr. R. Heymons (18) had published the result of his study of the development of certain rhynchotous forms. His conclusions are:—(1) the labial palps have entirely disappeared in the adult Rhynchota; (2) the so-called labial palps are secondary structures from the third segment of the proboscis; they appear in the embryo but they degenerate and disappear in the later stages. Leon, however, does not agree with these conclusions. Heymons has deduced them from the study of the comparative embryology of these forms; while Leon has come to his different conclusions from the study of their comparative anatomy. His conclusions are:—(1) The labial palps persist in the adult forms; (2) they have been discovered in *Nepa*, *Ranatra*, and certain Belostomidæ; (3) it is not possible for any secondary structures to originate at the same place where the primary structures had been before, and to perform the same function as the latter.

While the homologies of the labium were being discussed in Europe, a novel interpretation of the same structures was put forward in America by Prof. J. B. Smith (45), who had brought his special knowledge of the mouth-parts of Diptera to bear upon this question. He held that the proboscis was a part of the first maxillæ; the basal segment of the proboscis being the cardo; the second, subgalea; the third and the fourth, the two

segments of the galea. All that remained of the labium was the mentum—a boat-shaped process lying between the stylets. This was an original view, confined to Smith alone. It was shown, the next year, to be erroneous by Marlatt (34), and, after a few years, by Meek (36), according to whom the boat-shaped process—the mentum of Smith—was the pharynx.

Thus far no one has definitely demonstrated the presence or absence of the labial palps. All the recent writers are unanimous in the view that the proboscis is formed by the fusion of the second maxillæ, which consist of the submentum, mentum, paraglossæ, and ligulæ—the view held by Gerstfeldt long ago. But here unanimity ends, and different views prevail as to the existence of the labial palps.

(i.) Leon holds that they are present in the adult forms. He deals with this question from the anatomical standpoint.

(ii.) Heymons holds that the labial palps appear only in the embryonic stages, and disappear in the adult forms. He writes: "Wenn einigen Autoren auch gewisse Anhänge an der Unterlippe, also Palpi labiales angesprochen worden sind, so wird man sich diese Deutungen gegenüber skeptisch verhalten müssen, da weder die Entwicklungsgeschichte, noch die vergleichende Anatomie zu Gunsten solcher Ausnahmen sprechen."

*Maxillæ, or inner Borstenkiefer, or Stechborsten.*

Savigny long ago, and others who have followed him, have homologised the inner stylets of the Rhynchota with the first maxillæ of the biting insects. But they have not clearly shown what parts correspond to cardo, stipes, etc., and what becomes of the maxillary palps—which are conspicuously absent in the Hemiptera.

Kraepelin (25) held that the grooved inner stylets were mandibles, which formed the tube for suction, while the maxillæ were on the outside of the mandibles. This view is not now accepted.

Huxley (48) denied the homologies of the inner stylets with the first maxillæ of the other (biting) insects, because the former do not happen to possess the maxillary palps of the latter.

Mecznikow (49) has also denied the homologies of the internal and the external stylets in the Homoptera. According to him the true maxillæ and mandibles appear in the embryonic stages only, but they degenerate and disappear later on. Both stylets of the adults are produced from the retort-shaped ("retortenformigen") organs situated in the head. They are therefore not homologous with the maxillæ and the mandibles of the biting insects.

Witlaczil (50) has demonstrated, however, that the embryonic mandibles and maxillæ do not disappear at all, but persist in the adult stages, though there is a marked change in their position. In early stages they are situated on the outside, but later on they sink into the head and become entirely internal.

This sinking in, or involution, of these structures has been brought about by the greater development (overgrowth) of the clypeus and the labrum. The retort-shaped organs are nothing but the swollen bases of these stylets. Not only are these organs found in the Homoptera but they are also found in the Heteroptera; though in the latter they are not so prominent as in the former, owing to their degeneration. In the Homoptera they have been recently demonstrated by Davidson (9).

The fact that both the stylets sink into the head owing to the overgrowth of the clypeus, has been recently shown by Heymons.

The mandibles and the maxillæ, then, do not disappear but persist in the later stages, though in different positions. "Mandiblen und Maxillenladen ziehen sich bei den Rhynchoten in tiefe taschenförmigen Hohlräumen zurück und scheiden die chitinosen Stechborsten aus." Thus writes Heymons. The retort-shaped organs of Meczniow, in the Homoptera, are the "taschenförmigen Hohlräumen" of Heymons, in the Hemiptera in general.

Prof. J. B. Smith (45) was the first to call attention to the fact that the maxillary stylets form but a part of the first maxillæ. Each maxilla consists of two parts: the maxillary sclerite or segment, and the maxillary stylet; but he was not able to identify them separately.

It was not until Heymons had published his "Beiträge zur Morphologie und Entwicklungsgeschichte der Rhynchoten" (20), that the relation between the maxillary segment or plate and the maxillary stylet was clearly understood. According to Smith the two pairs of stylets with the lateral (maxillary) sclerites posterior to the mandibles, together with the proboscis, represent the first maxillæ; the stylets representing the lacinia and stipes; the sclerite representing the palpus and the proboscis. He had made both the stylets arise from the same place. He is apparently led astray in his interpretation by a faulty dissection, which was shown to be the case by Marlatt (34).

Heymons is the first writer to explain clearly the homologies of the first maxillæ. He has studied their development in certain Hemipterous (both Heteropterous and Homopterous) forms. He has clearly demonstrated that a maxilla arises as a single structure, but that soon after it is divided into two parts:—(i.) a median piece, or maxillenlade; (ii.) a lateral piece, maxillenhöcker, or maxillary plate (segment).

(i.) *The maxillenlade*.—This becomes elongated and transformed into a long tapering stylet, two of which (one from either side) combine together to form two tubes, one for suction of the sap, and the other for ejection of the saliva.

(ii.) *The maxillary plate*.—This represents the stem of the maxilla (cardo and stipes) of the biting insects. It forms the antero-lateral piece of the head-wall, and has therefore nothing to do with the mouth-parts proper—except in so far as it forms the support to the protractor muscles of the maxillæ.

*The Maxillary Palps.*

The presence of maxillary palps is one of the distinguishing features of the first maxillæ of the biting insects, but they have completely disappeared in the Rhynchota. The maxillæ become elongated in these insects, and work inside plant or animal tissues. Sensory apparatus in the form of palps is superfluous.

Maxillary palps had been described long ago by Ratzeburg (1827-34) in certain species. Each palp was found to be three-jointed. Burmeister (1835) had, however, found that they were not palps but horny tubercles marking the attachment of the maxillary muscles.

Heymons has, as far as possible, elucidated the question of the maxillary palps. According to Smith, the maxillary sclerite and the palps fused together to form one structure. Heymons, however, holds another view. The maxillary palp is distinct from the sclerite, and the maxillary plate has a process (processus maxillaris) which he interprets to be the remains of a maxillary palp. In some species of Tingidæ there are certain processes—which were taken to represent the labial palps—but which are now regarded as the maxillary palps.

Rudimentary palps are present in some Hydrocoridæ—in *Nepa* they are onion-shaped—but in *Gymnocerata* they are identified with the Bucculæ (?).

*Mandibles, or external Stechborsten.*

These were recognised as such long ago, though Kraepelin (25) had mistaken them for the maxillæ, and had therefore made them the sucking organs. The views of Mecznirow have been given above. Prof. Smith, while working on the nymph of *Cicada*, described a mandibular sclerite corresponding to that of the maxilla, and a mandibular stylet also corresponding to the maxillary. Heymons, too, has described the mandibular sclerite (lamina mandibularis) and stylet in *Cicada*. The mandibular sclerite is very well marked in the Homoptera, but in the Heteroptera it is not present at all, or is rudimentary. These structures are distinct in the later stages, though they have been derived from the same structure in the embryo; the connection between them is lost. The protractors of the mandibular stylets are not attached to the mandibles but to their levers at one end and, at the other, to the mandibular sclerite.

This interpretation of Heymons has been recently called in question by Muir and Kershaw (22, 23, 24). The so-called mandibular plates are not derived, according to them, from the mandibles, and therefore have no relation whatever to them. They are mandibular folds or sulci.

The most recent view therefore is:—(i.) The mandibles of the biting insects are represented by the external stylets. (ii.) The mandibles are not divided into two parts, one corresponding to the

cardo and stipes of the maxillæ and the other to the maxillary stylet. (iii.) The protractor muscles of the mandibles are attached to the levers and not to the mandibles.

### *Labrum.*

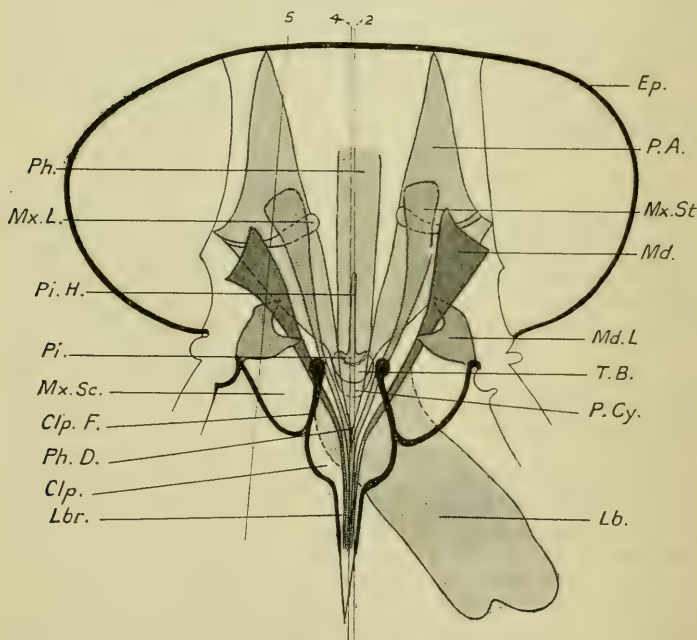
This is the least disputed structure. Its homology with the labrum of the mandibulate insects has been determined with certainty. It is not, however, one of the appendages of the head but a continuation of the clypeal sclerite, from which it is not easily to be distinguished externally.

### THE MORPHOLOGY OF THE HEAD. (Text-fig. 1.)

The head of *Lygus pabulinus* consists of the following parts:—

- (1) *The Epicranium.*—This lies between the two large eyes. It is continued into
- (2) *The Clypeus.* (The frons, the intermediate portion between

Text-figure 1.



*Lygus pabulinus.*

Mount of the whole head, macerated in potash (10 per cent.), and stained with saturated picric in 90 per cent. alcohol; showing the internal chitinous structures. Ob. 3 & Oc. 4.

The lines numbered 2, 4, 5 indicate the planes of the longitudinal sections shown in the corresponding figures.

epicranium and clypeus, is not well marked.) The sides of the clypeus have sunk into the head, forming clypeal folds to which the protractors of the mandibles are attached, and which are fused with the ventral wall of the pharynx (text-fig. 17, Clp.F.).

(3) *The Labrum*.—This is merely a continuation of the clypeus, and there is no sign of external differentiation between the two structures. It extends as far as the first segment of the labium, and tapers to a point, the base being broader. It has rather a deep groove underneath to hold the stylets in place, since the labial groove at this point is too shallow and flat to do this. There are three external longitudinal ridges on its dorsal surface; its sides are ornamented with small rounded lobes, and its surface

### *Explanation of Lettering.*

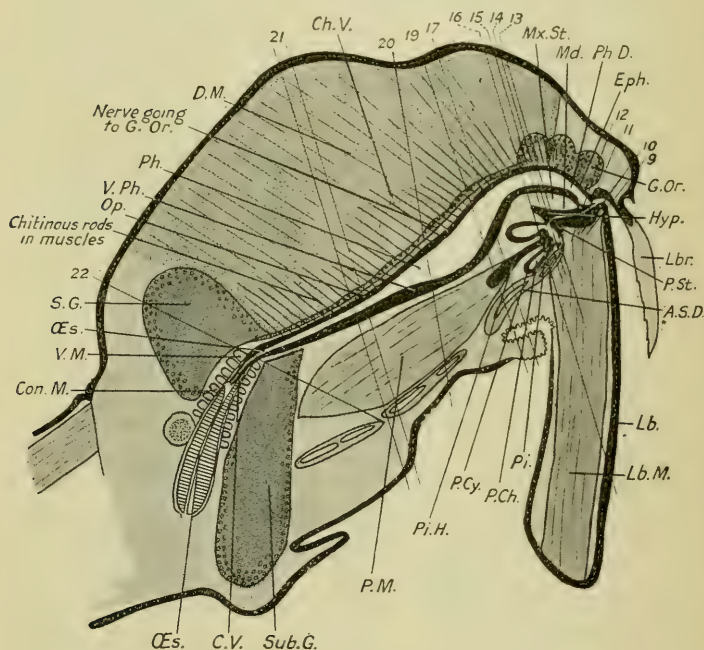
|   |  |
|---|--|
| A.M. Antagonistic Muscles.                | Mx.C. Cavity of the Maxillary Stylet.        |
| A.S.D. Afferent Salivary Duct.            | Mx.F. Maxillary Fold.                        |
| A.W.P. Anterior Wall of the Pump-chamber. | Mx.L. Maxillary Lever.                       |
| Bu.F. Buccal Fold.                        | Mx.P. Protractors of the Maxillary Stylets.  |
| Cam. Cambium.                             | Mx.R. Retractors of the Maxillary Stylets.   |
| C.C. Circumoesophageal Commissure.        | Mx.Md.Art. Maxillo-mandibular Articulation.  |
| Clp. Clypeo-labrum.                       | Mx.Md.M. Maxillo-mandibular Muscles.         |
| Clp.Lbr. Clypeo-labrum.                   | Mx.Sc. Maxillary Sclerite.                   |
| Clp.F. Clypeal Fold.                      | Mx.Sh. Maxillary Sheaths.                    |
| Clp.Sc. Clypeal Sclerite.                 | Mx.St. Maxillary Stylets.                    |
| Con.M. Constrictor Muscles.               | Op. Operculum.                               |
| Cort. Cortex.                             | Es. Esophagus.                               |
| Cri.Pl. Cribriform Plate.                 | P.A. Posterior Arms of the Tentorium.        |
| C.V. Cardiac Valve.                       | P.Cy. Pump-cylinder.                         |
| D.A. Dorsal Arms of the Tentorium.        | P.Ch. Pump-chamber.                          |
| D.M. Divaricator Muscles.                 | Pi. Piston.                                  |
| E.C. Ejection Canal.                      | Pi.H. Handle of the Piston.                  |
| Ep. Epicranium.                           | Ph.D. Pharyngeal Duct.                       |
| Epd. Epidermis.                           | Ph. Pharynx proper.                          |
| Eph. Epipharynx.                          | Phl. Phloem.                                 |
| End. Endodermis.                          | P.M. Pump Muscles.                           |
| E.S.D. Efferent Salivary Duct.            | Poc.Or. Retort-shaped Organs.                |
| G.Or. Gustatory Organs.                   | P.St. Pump-stem.                             |
| Hyp. Hypopharynx.                         | P.W.P. Posterior Wall of the Pump-chamber.   |
| L.A.S.D. Lumen of the A.S.D.              | S.St. Maxillary Process or Supporting Strut. |
| Lb. Labium.                               | Su.C. Suction Canal.                         |
| Lb.G. Labial Groove.                      | S.G. Supra-oesophageal Ganglion.             |
| Lb.M. Labial Muscles.                     | Sub.G. Sub-oesophageal Ganglion.             |
| Lbr. Labrum.                              | S.D. Salivary Duct.                          |
| Lig.A.M. Ligament for A.M.                | T.B. Body of the Tentorium.                  |
| Lig. Ligament for D.M.                    | Tr. Trachea.                                 |
| L.P.M. Ligament for P.M.                  | T.Mx. Tip of the Maxillary Stylet.           |
| Md. Mandibles.                            | T.Md. Tip of the Mandible.                   |
| Md.Art. Mandibular Articulation.          | V.Ph. "V" or ventral wall of the Pharynx.    |
| Md.L. Mandibular Lever.                   | V.M. Valvular muscles.                       |
| Md.P. Protractors of the Mandibles.       | Xyl. Xylem.                                  |
| Md.R. Retractors of the Mandibles.        |  |
| Md.C. Cavity of the Mandibles.            |  |
| Md.H. Hooks of the Mandibles.             |  |
| Md.Sh. Mandibular Sheath.                 |  |
| M.A.S.D. Mouth of the A.S.D.              |  |

is covered dorsally with small hairs or papillæ, and is very smooth ventrally. It is complementary in its function to the labium, *i. e.* it is applied closely against the labium to form the deep groove which keeps the stylets in place and prevents their lateral movement (text-fig. 9, Lbr.).

(4) *The Maxillary Sclerite*.—This is situated laterally to the epiceranium just below the eyes, and forms the lateral boundary of the mouth. As stated above, it is one of the parts of the embryonic maxilla. The protractors of the maxillæ are attached to it.

(5) *The Labium* (text-figs. 1, 29, Lb.).—This structure consists of four segments. The first is broader and shorter and has practically no groove, or, if there is any, it is very shallow and flat. The first joint—*i. e.* the joint between the first and second segments—is swollen, and this swelling is due to a great development of chitinous “tendons” to which the labial muscles are

Text-figure 2.



*Lygus pabulinus.*

Diagrammatic median longitudinal section. Ob. 3 & Oc. 4.

The lines numbered 9 to 22 indicate the levels of the sections shown in the corresponding figures.

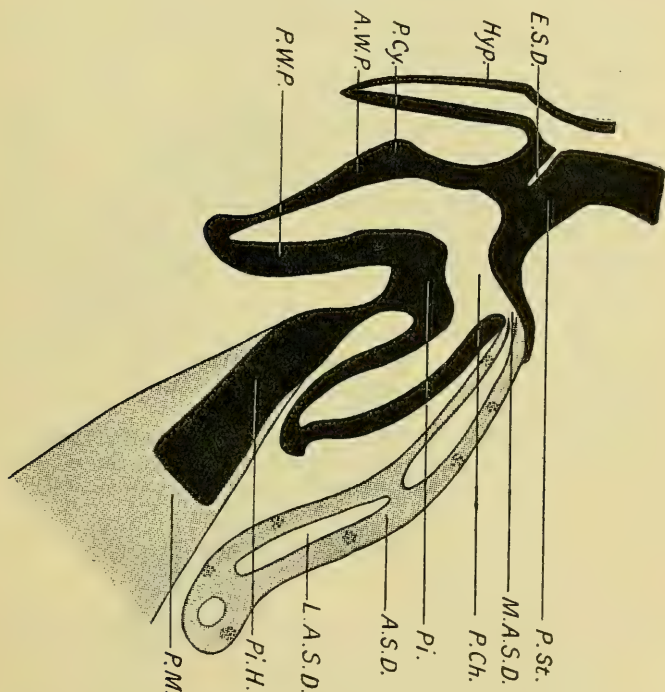
N.B.—In all the sections the microscope tube is not drawn out to its proper length.

For explanation of the lettering see p. 693.

attached (text-figs. 2, 16, Lb.M.). Moreover, it acts as a hinge upon which the whole of the labium is bent and doubled. This is one of the characteristic features of the insect. It enables the insect to get at the required tissues of a plant. The stylets are thrust into tissues containing food, the depth of which below the surface varies in different parts of the same plant. The deeper such tissue lies, the greater is the bend of the labium at the first joint. Its bend is scarcely appreciable when the insect is sucking sap from tissues which are superficial.

The stylets cannot be increased in length, but this mechanism by shortening the proboscis enables the insect artificially to protrude them further into the plant tissue. The labial muscles facilitate this bending (text-figs. 2, 16, Lb.M.).

Text-figure 3.

Pump-apparatus of *Lygus pabulinus*.

Sagittal section.

For explanation of the lettering see p. 693.

The second, the third, and the fourth segments are long and narrow and gradually taper to a point. The groove, which is shallow and flat in the first segment, begins to deepen in the

second, and, in the last segment, forms a tube enclosing the stylets. Cross-sections of the last segment show one tube within the other. The inner tube enclosing the stylets is formed by the groove; and the labium is the outer tube which encloses the former (text-fig. 8, Lb.G.).

The tip of the labium is encircled with bristles which are of two sorts, fine and stiff. They are arranged in a definite way, and function as sensory hairs. The insect feels the surface of a leaf with them before thrusting its stylets into it.

The labrum and the labium together keep the stylets in place. In the first segment, where the labial groove is too flat and shallow to do it and where the labium has a bend inwards, thereby leaving the stylets free, the labrum encloses them in its groove. Distally the labium takes over this function of holding the stylets, since its groove becomes deeper and deeper. Thus the stylets are always found in the groove of one or the other, and are prevented from that lateral movement which would make piercing and sucking impossible.

The labium protects the stylets in the groove, but its more important function is very ingenious. The stylets are very thin, needle-like structures which have, however, to pierce the tough and cuticularised epidermis of a leaf. As they are very delicate, they would bend in the act of piercing, were they not enclosed in the proboscis. The lumen of the tubular tip of the proboscis is so small that the stylets fit into it tightly (text-fig. 8). There is no empty space in it for them to bend. The tip of the labium is closely applied to the surface of the leaf; the protractor muscles of the stylets contract; and the stylets are forced out of the proboscis and driven against the epidermis, which they cannot fail to pierce. Once in, their forward progress to the required tissue is mechanical owing to the bend of the labium at the first joint.

It is thus obvious that the labium is an important structure in the sucking apparatus of this insect; it is one, moreover, on the structure of which stress has not been laid by previous writers.

(6) *The Stylets, or Stechborsten.* (Text-figs. 1, 6, 23.)

(I) MORPHOLOGY.

(a) *The Maxillary Stylets or Internal Stechborsten.* (Text-figs. 1, 5, 6, 23, Mx.St.)

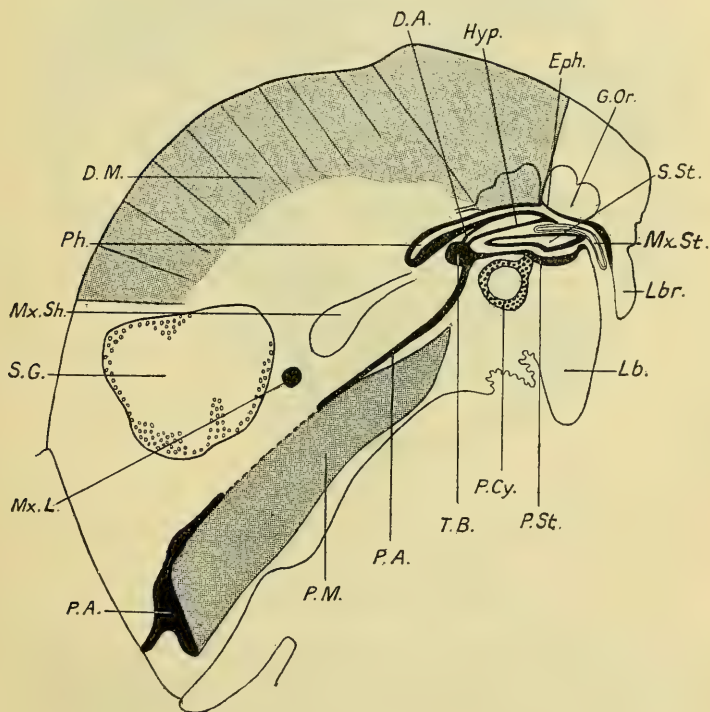
It is shown above that the stylet is a part of the maxilla and not the maxilla itself. Each maxilla is divided, in the embryonic stage, into two parts, one of which forms the stylet or Stechborste. The maxillary stylets are situated between the pharynx and the mandibles on either side. They are not, however, on the same level with either of them: they are just above the pharynx and below the mandibles. They are hollow, and their cavities are continuous with the body-cavity.

Each of them consists of :—

- (i.) an external part, projecting beyond the head and forming the complementary half of the sucking tube ;
- (ii.) an internal part, separate from its complement and going to one side of the pharynx.

(i.) The external part. This tapers to a fine and curved point. In cross-sections it shows a groove which is divided into two gutters by a longitudinal ridge which runs through it, from end to end. In short, the whole structure looks in cross-section like a **W**, and one groove is thus divided into two small, separate, and non-intercommunicating groovelets. The two stylets from either side come together and by approximation of these groovelets form two complete tubes—one dorsal facing the labrum and functioning

Text-figure 4.



*Lygus pabulinus*.

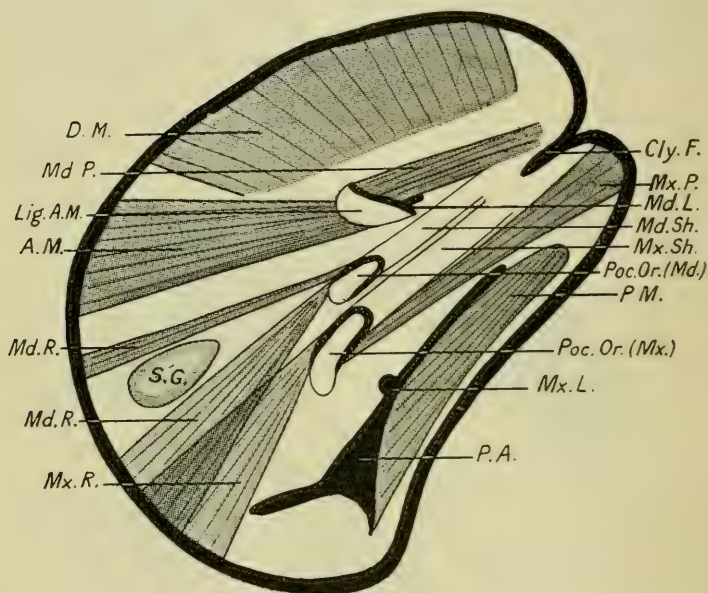
Nearly median longitudinal section, showing the supporting structure, the body of the tentorium, the pump muscles, etc. Ob. 3 & Oc. 4.

For explanation of the lettering see p. 693.

as the suction-canal, and one ventral facing the labium, functioning as the ejection-canal, through which saliva is forced down by the salivary pump (text-figs. 8, 9, 10, Mx.St., Su.C., E.C.).

There are not any extra-chitinous structures to unite the two stylets to form the canals; the three ridges of each stylet apparently uniting with those of the other. They can be detached from one another with a little force. This fusion may easily be seen in a series of cross-sections.

Text-figure 5.



*Lygus pabulinus.*

Lateral longitudinal section, showing the arrangement of the muscles in the head. Ob. 3 & Oc. 4.

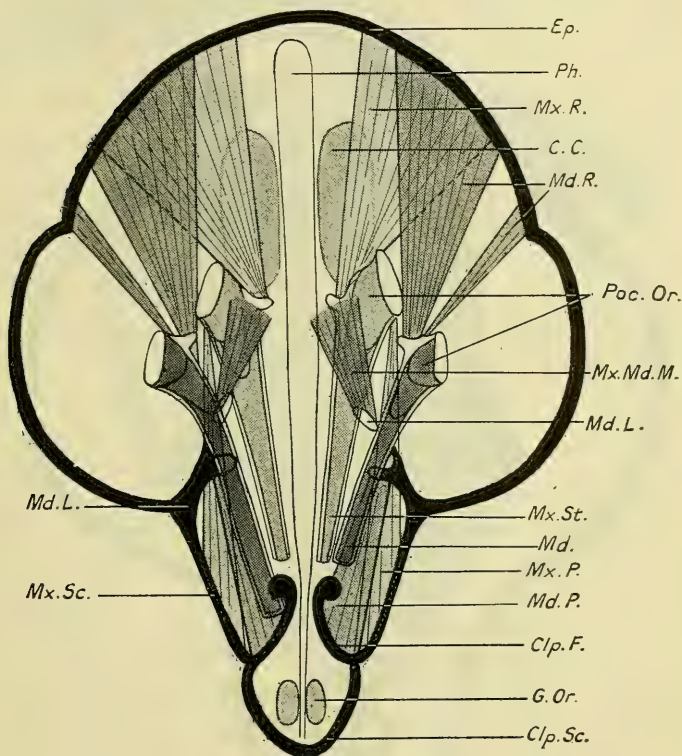
For explanation of the lettering see p. 693.

The tips of the stylets are smooth and lancet-shaped, as might be expected from their function (text-fig. 23). In certain aquatic forms they are ornamented with minute incurved hooks (O. Geisse (13). Within the plant-tissues the tips of the maxillæ do not end simultaneously; one of them is pushed a little further than the other (text-fig. 25).

(ii.) The internal part. This lies within the head. It gets gradually flatter and broader when it is traced back. Each stylet

ends internally in a swollen base. These swollen bases, which are oval, have their importance in history, which has been referred to above. They are known as the retort-shaped organs of Mecznirow, or the Taschen-formigen organs of Heymons (text-figs. 5, 6, 20, 21, Poc.Or.).

Text-figure 6.



*Lygus pabulinus.*

Reconstructed from numerous vertical sections, showing the relation of the muscles to the stylets, the pump, etc. Ob. 3 & Oc. 4.

For explanation of the lettering see p. 693.

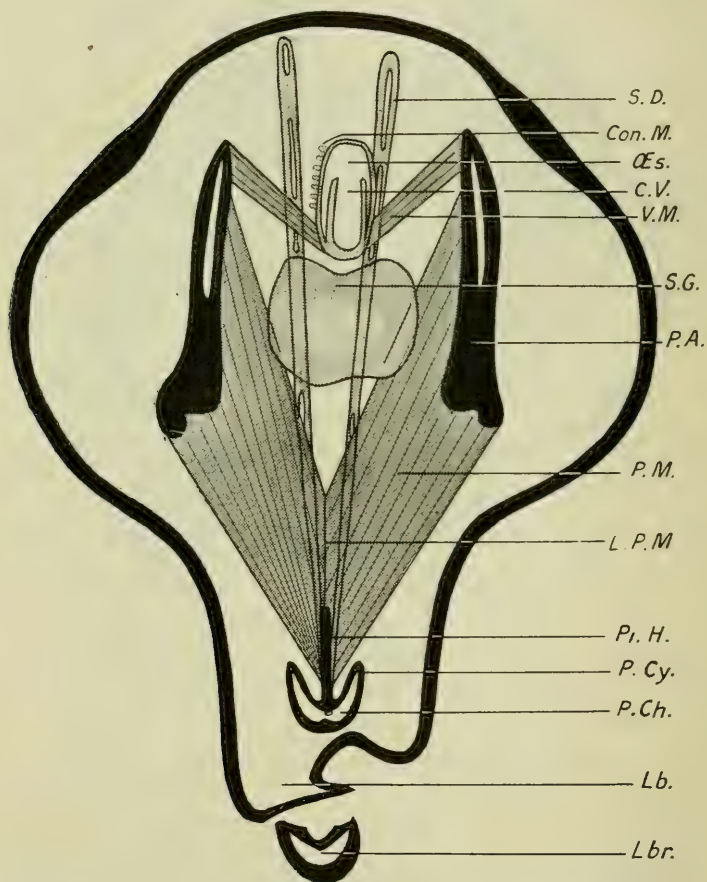
There is no trace of the maxillary groove upon the swollen bases, but it begins a little below. The structure of the groove is the same here as described in the external part, though on a minute scale. The stylets are, of course, separate in the head, as they pass one on either side of the pharynx (text-figs. 1, 5, 6, 11-19).

## (b) The Mandibles. (Text-figs. 1, 5, 6, 23, Md.)

These are single structures from the beginning. The embryonic mandibles are the adult mandibles, there being no mandibular sclerite. The present view of their homologies has been given above.

Their external structure corresponds with that of the maxillæ. They lie just above them and do not go so deep into the head.

Text-figure 7.

*Lygus pabulinus.*

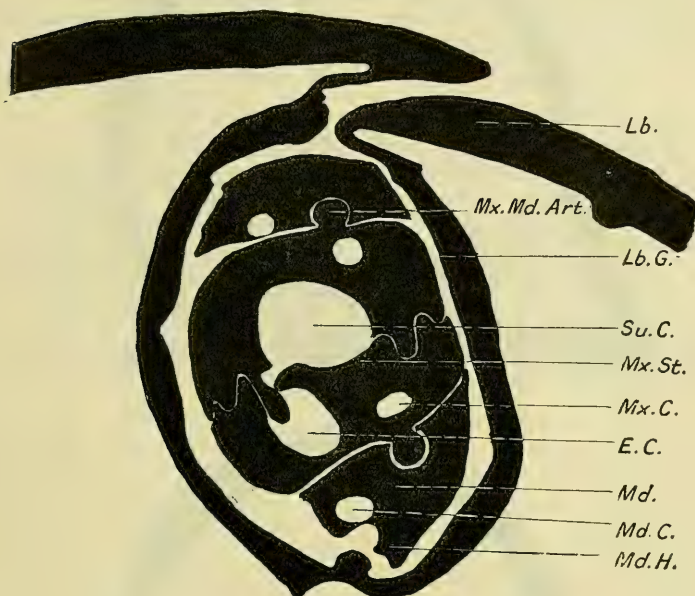
Reconstructed from numerous vertical sections, showing the relation of the muscles to the stylets, the pump, etc. Ob. 3 & Oc. 3.

For explanation of the lettering see p. 693.

They are flat and hollow and end in retort-shaped organs like the maxillary stylets; but unlike them:—

(i.) They never form tubes, as they do not unite and have no grooves on them. They are separate from end to end. Each of

Text-figure 8.



*Lygus pabulinus*.

Transverse section of the tip of the labium. Immersion-lens & Oc. 4.

For explanation of the lettering see p. 693.

Text-figure 9.

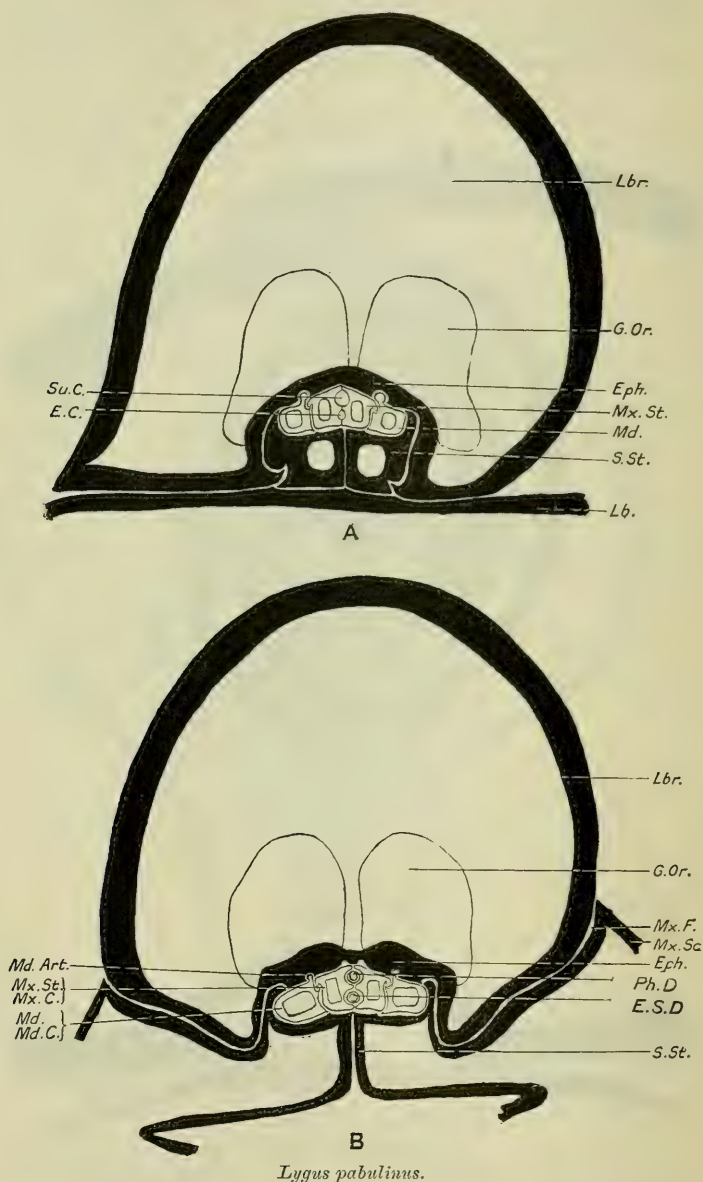


*Lygus pabulinus*.

Transverse section of the tip of the labium, showing the labrum and the labium enclosing the stylets. Immersion & Oc. 4.

For explanation of the lettering see p. 693.

Text-figure 10.



A & B. Transverse sections, showing the epipharynx, gustatory organs, the pharyngeal duct, the efferent salivary duct, etc. Ob. 6 & Oc. 4.

For explanation of the lettering see p. 693.

them is connected with the maxilla of its side by an interlocking arrangement.

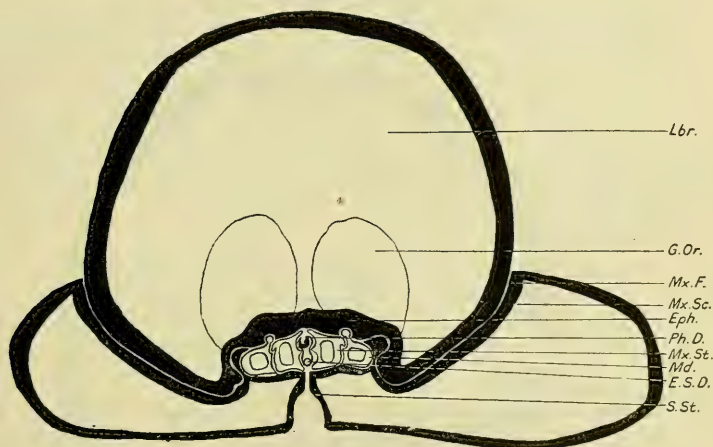
(ii.) The tips, which are pointed, are ornamented with recurved hooks, the number and size of which seem to vary in different species. The number varies from 7 to 9 in *L. pabulinus*. They are bigger towards the tips of the mandibles but get reduced posteriorly. The hooks will tear the tissues when withdrawn from them with the maxillary stylets, though this arrangement will not prevent their entrance into tissues. Their function will be clear later on (text-fig. 23, T.Md.).

## (II.) ANATOMY.

The stylets are chitinous, the chitin being lined by the chitinous epithelium which forms a continuous layer under it. Each of the stylets is enclosed in a sheath which is continuous with the integument of the head. This shows that both stylets have been invaginated in the course of their development, as is demonstrated by Heymons (text-figs. 4-7, Mx.Sh., Md.).

*The retort-shaped organs.* (Text-figs. 5, 6, 20, 21, Poc.Or.).—These are characteristic of the Rhynchota (Heteroptera and Homoptera). Mecznikow (49) has described them as the structures

Text-figure 11.



*Lygus pabulinus.*

Transverse section, showing thickening of the floor of the pharyngeal duct (cf. figs. 10 A and 12).

For explanation of the lettering see p. 693.

from which the new maxillæ and the mandibles are formed, but, as is shown above, they are not new structures at all. They are nothing, in fact, but the swollen bases of the stylets, the swelling being formed during development. They are the same as the Taschen-formigen structures of Heymons.

They are oval and curved laterally outward. They are found

in the middle part of the head and show a curious structure in cross-sections, appearing as areas of glandular tissue surrounded by a chitinous ring which disappears in more distal sections.

*The Interlocking Arrangement of the Stylets (external and internal).* (Text-figs. 8-16, Mx.Md.Art., Md.Art.).—As shown by Davidson (9), the maxillæ and the mandibles of *Schizoneura lanigera* are round and lie loose from each other. In *Lygus pabulinus*, however, they are never separate outside the head, but are interlocked. Within the head the members of both pairs lie loose; the maxillæ and the mandibles being smooth and oblong without any processes (text-figs. 18-20, Md., Mx.St.). Anteriorly in the labral region, they have a different structure. The mandibles give rise dorsally to longitudinal ridges (which in section appear as knobbed processes), which attach them to the labrum or epipharynx. These disappear, however, beyond the labrum. This arrangement demonstrates the importance of the labrum in keeping the stylets in place and preventing their lateral sliding.

The maxillæ also have small processes, of a similar nature and function, which attach them firmly to the mandibles. These structures are clearly visible in cross-sections. In the fourth segment of the labium they are more pronounced.

It is obvious, therefore, that the mandibles and maxillæ are inseparably attached to one another, and, the space between them being exceedingly small, friction will ensure their simultaneously working up and down; the mandibles accompanying the maxillæ all the time and all the way in and out of the plant-tissues, unless a differential force be applied\*. Inside the head they are always prevented from lateral movement by structures which are invaginations or infoldings of the outer walls of the head, and which enclose them successively at different levels.

These folds are formed by:—

- (i.) The hypopharynx. (Text-figs. 13-15, Hyp.)
- (ii.) The buccal fold. (Text-figs. 16-19, Bu.F.)
- (iii.) The labial fold or the maxillary fold, formed by the infolding of the maxillary sclerite. (Text-figs. 16-19, Mx.F.)

These are very prominent structures in cross-sections of the head. They are not, however, found in the heads of those forms which require lateral movements of their mouth-parts, *i. e.*, in the biting insects.

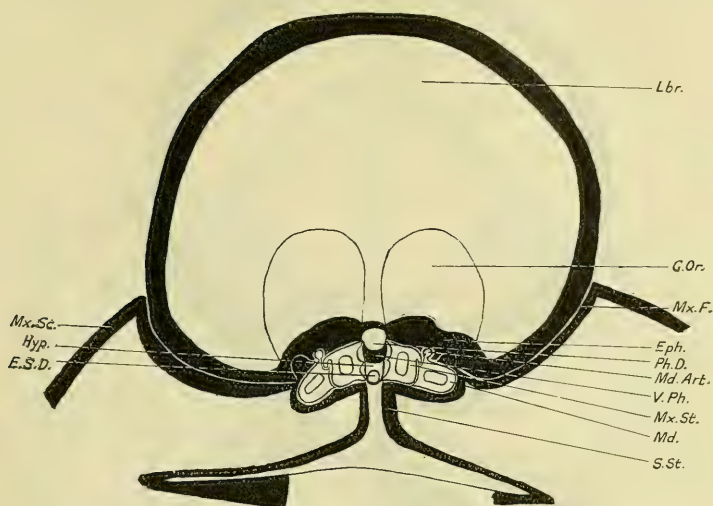
#### THE TENTORIUM OR ENDOSKELETON.

(Text-figs. 1, 4, 6, 7, 17, 19-22.)

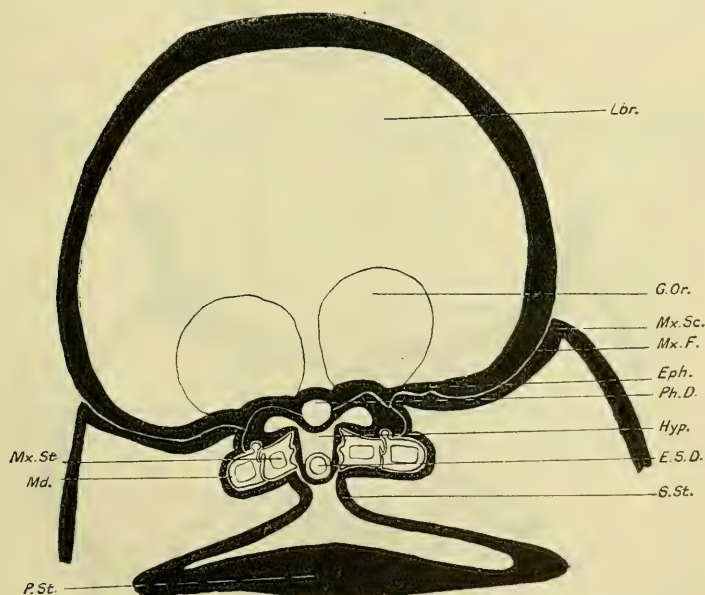
This has already been described by various writers: Burmeister, Wedde, Léon, Bugnion, etc. Its description by Comstock and

\* The existence of such a force will be demonstrated later on.

## Text-figures 12 and 13.

*Lygus pabulinus*.

Text-fig. 12.—Transverse section, showing the maxillo-mandibular articulation, the mandibular articulation, the pump-chamber, the pump-stem, etc. Ob. 6 & Oc. 4.

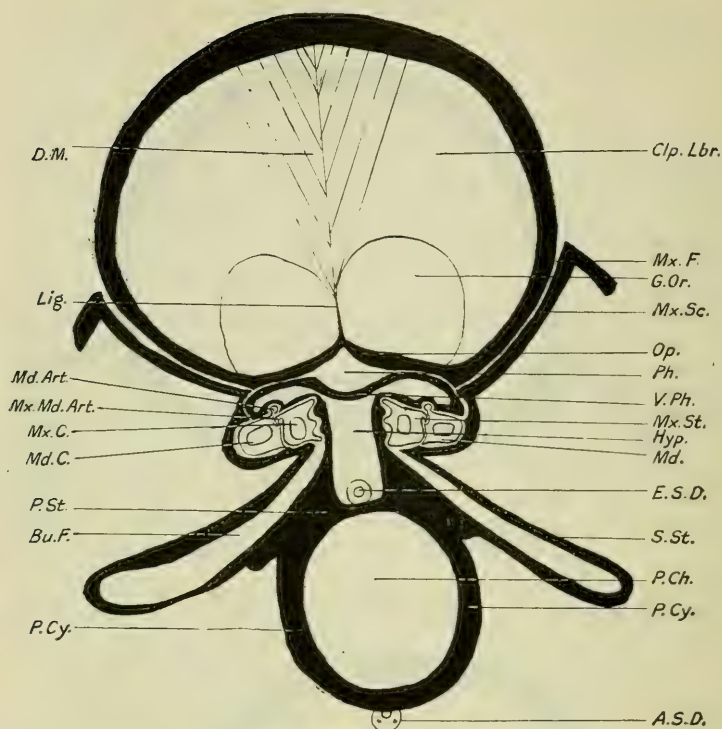


Text-fig. 13.—Transverse section, showing the maxillo-mandibular articulation, the mandibular articulation, the pump-chamber, the pump-stem, etc. Ob. 6 & Oc. 4.

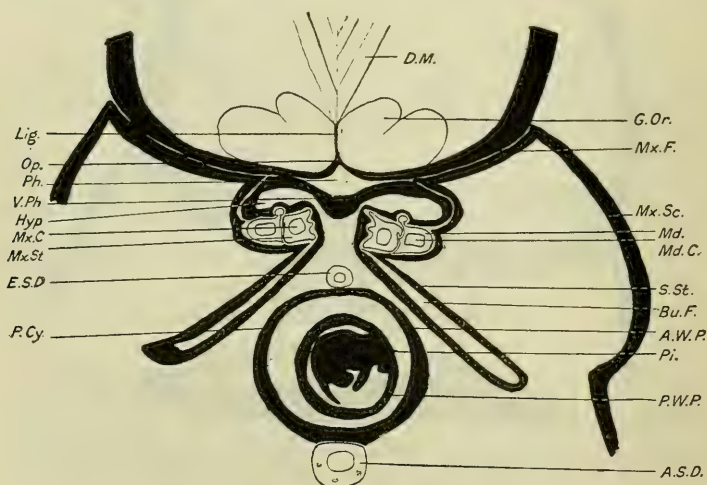
For explanation of the lettering see p. 693.

Text-figures 14 and 15.

*Lygus pabulinus*.



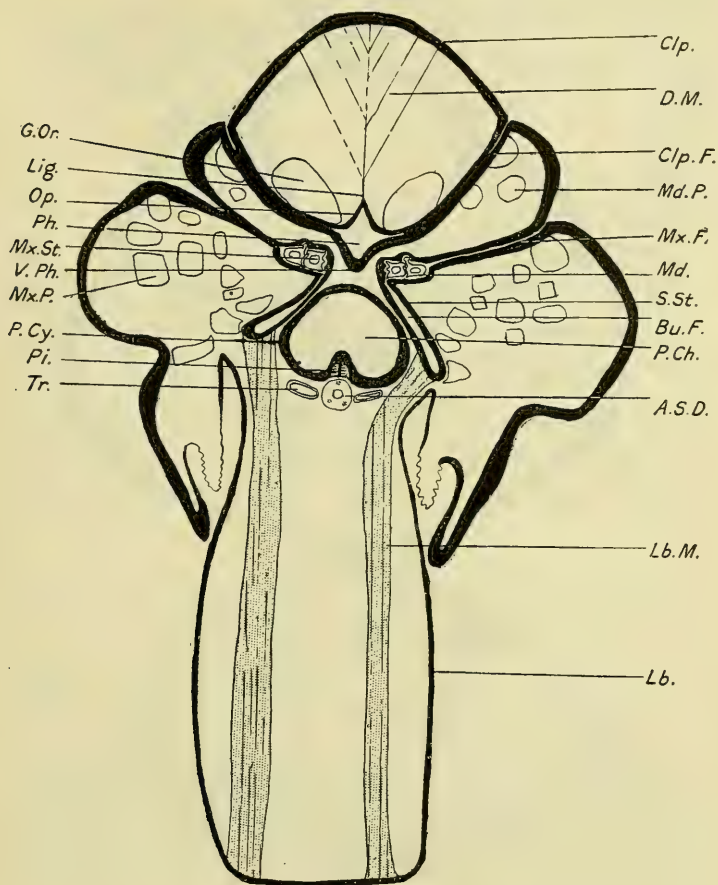
Text-fig. 14.—Transverse section, showing the maxillo-mandibular articulation, the mandibular articulation, the pump-chamber, the pump-stem, etc. Ob. 6 & Oc. 4.



Text-fig. 15.—Transverse section, showing the piston, the afferent salivary duct, the divaricators, the protractors of the stylets, the labial muscle, etc. Ob. 6 & Oc. 4.  
For explanation of the lettering see p. 693.

Kocchi (6) has the special advantage of a simple terminology, which I have accordingly adopted here.

Text-figure 16.

*Lygus pabulinus*.

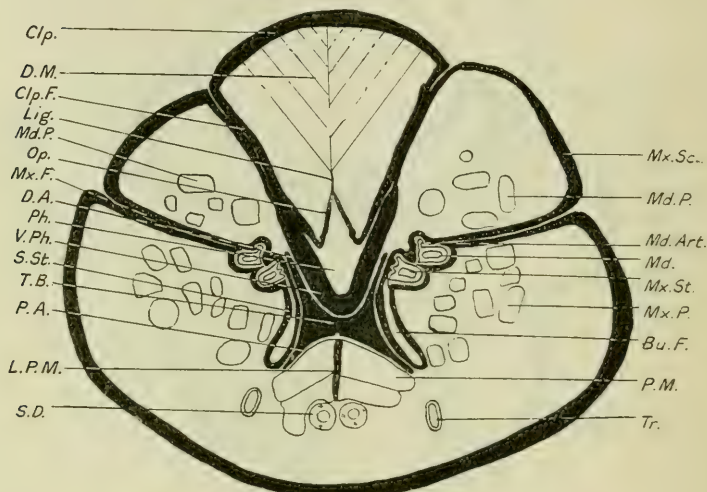
Transverse section, showing the piston, the afferent salivary duct, the divaricators, the protractors of the stylets, the labial muscle, etc. Ob. 3 & Oc. 4.

For explanation of the lettering see p. 693.

The endoskeleton of *Lygus pabulinus* consists of hollow chitinous rods which are covered by a thin hypodermal (chitinogenous) layer. They are nothing but involutions of the chitin of the head, and therefore are called "Apodemes." The fact that the tentorium consists of these hollow structures is very significant.

Great stresses have to be borne, and economy of skeletal material has been effected and a maximum of rigidity attained, by forming this material into hollow tubes instead of into solid rods. Many parallel cases may be instanced from the plant kingdom—of hollow stems which resist great stress.

Text-figure 17.

*Lygus pabulinus.*

Transverse section, showing the clypeal folds, salivary ducts. Ob. 2 & Oc. 12.

For explanation of the lettering see p. 693.

The tentorium consists of the following parts:—

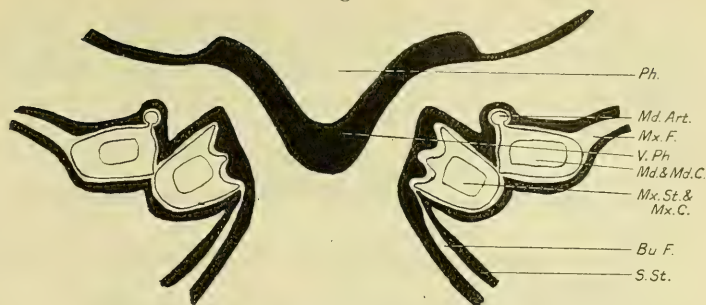
(I.) The Body of the Tentorium, or Tentorium proper. (Text-figs. 1, 4, 17, 19, T.B.)

This is formed by the fusion of the different arms of the endoskeleton. It lies between the pump below and the pharynx above. It is found at the place where, if it were absent, there would be great probability of the pharynx on the one hand and the pump on the other, being dragged out of their positions by contractions of their powerful muscles. It furnishes a firm support for both these organs.

Its structure is interesting; both its surfaces (dorsal toward the pharynx, and ventral facing the pump) are curved and form two grooves. The groove facing the pharynx is V-shaped and corresponds exactly to the shape of the ventral wall of the pharynx, which fits closely into it. They are joined together by connective tissue.

The shape of the other groove, *i.e.* the ventral one, is roughly semicircular, and into it the pump is wedged, and kept there by connective tissue.

Text-figure 18.

*Lygus pabulinus*.

Part of a transverse section, showing the stylets magnified, and their arrangement. Ob. 3 & Oc. 12.

For explanation of the lettering see p. 693.

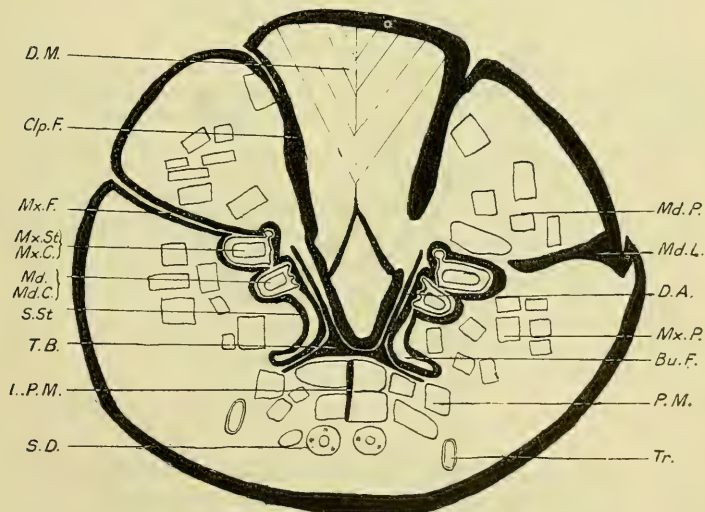
(II.) The Dorsal Arms. (Text-figs. 4, 17, 18, D.A.)

These are short and do not reach the walls of the head but lie free within it. The sides of the V (*i.e.*, the ventral wall of the pharynx) are firmly attached to these arms by connective tissue.

(III.) The Posterior Arms. (Text-figs. 1, 4, 5, 7, 20-22, P.A.)

These are more important than the dorsal arms. They run

Text-figure 19.

*Lygus pabulinus*.

Transverse section, showing the mandibular levers, stylets magnified, and their arrangement. Ob. 3 & Oc. 12.

For explanation of the lettering see p. 693.

posteriorly from the tentorial body to the posterior wall of the head. They are broad, elongate, and flattened dorso-ventrally. The pharynx is supported by them (text-fig. 20) just behind the tentorial body, their connection with the pharynx being through connective tissue.

At the far end, towards the wall of the head, the arms begin to bifurcate, one armlet going straight to the posterior wall and the other to the side of the head (text-fig. 5).

Their functions are very important in the mechanism of suction :—

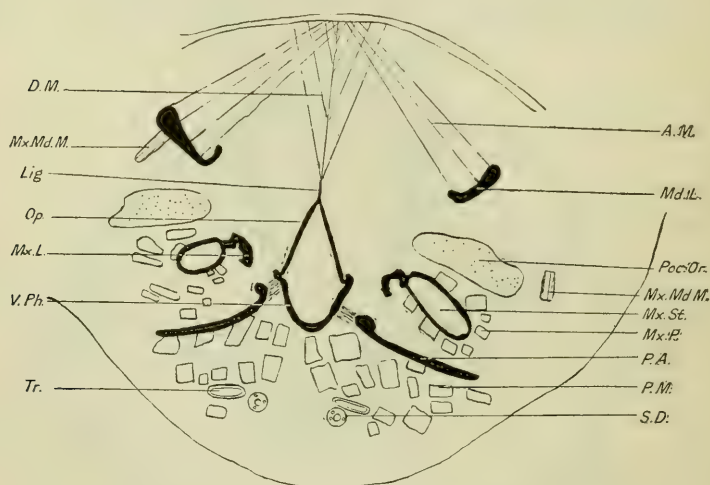
- (i.) They support the pharynx at the place where there is great tension.
- (ii.) The pump muscles are attached to them ventrally.
- (iii.) The valvular muscles find support in them.
- (iv.) The maxillary levers are supported by them.

It will be seen that the pharynx has support on all sides, *i. e.* ventrally, laterally, and dorsally (see below).

(IV.) The Levers. (Text-figs. 1, 5, 6, 19, 20, Mx.L., Md.L.)

Besides the tentorium proper, there are other chitinous structures which are connected to the outer and inner stylets. They

Text-figure 20.



*Lygus pabulinus.*

Transverse section, showing the antagonistic muscles, the retort-shaped organs, the posterior arms of the tentorium, etc. Ob. 3 & Oc. 12.

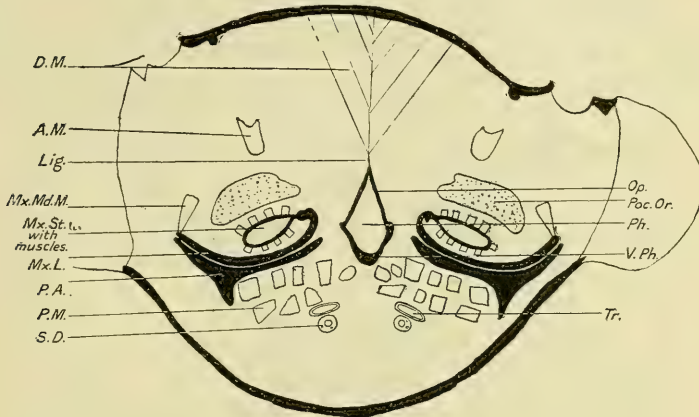
For explanation of the lettering see p. 693.

are known as the mandibular and the maxillary levers, and are placed at right angles to the direction of the stylets.

## (A) The Mandibular Levers. (Text-fig. 19, Md.L.)

These are attached proximally to the lateral wall, or maxillary sclerite, just below the bases of the antennæ, and distally to the mandibles through a ligament. Their distal connection enables the levers to pull down the mandibles when the protractor muscles,

Text-figure 21.

*Lygus pabulinus*.

Transverse section, showing the maxillary levers, etc. Ob. 3 & Oc. 8.

For explanation of the lettering see p. 693.

which are attached to the former, contract. Proximally, at the bases of the levers, there is no hinge-like device but, on the contrary, they are fused with the sclerite. They are bifurcated distally, the mandibles passing through the fork.

Their functions are:—

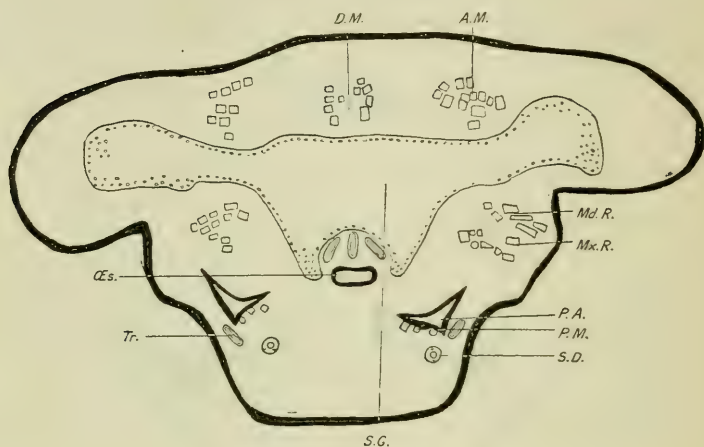
- (i.) They give attachment to the protractor muscles of the mandibles, which muscles are attached to the distal ends only.
- (ii.) The maxillo-mandibular muscles are attached to them.  
(Text-figs. 20, 21, Mx.Md.M.)
- (iii.) The antagonistic muscles, which serve to bring back the levers to their normal positions, are also attached to them.  
(Text-figs. 5, 20, A.M.)
- (iv.) The mandibles are supported by them.

## (B) The Maxillary Levers. (Text-figs. 1, 5, 21, Mx.L.)

These are narrow and elongate, and have no connection with the lateral walls of the head. Their proximal attachment is to the posterior arms of the tentorium, and distally they are connected with the maxillæ. They taper gradually towards their

bases, and are curved as they pass below the maxillary stylets, to which they are closely applied.

Text-figure 22.

*Lygus pabulinus.*

Transverse section, showing the supra-oesophageal ganglion, the retractor muscles, etc. Ob. 3 & Oc. 8.

For explanation of the lettering see p. 693.

Their relations are:—

- (i.) They support the maxillary stylets.
- (ii.) The maxillo-mandibular muscles are attached to them.
- (iii.) They never give attachment to any of the maxillary muscles, which are attached to the maxillary stylets themselves.

### THE MUSCLES OF THE HEAD.

The musculature of the head is very complicated. The diversity of the muscles is correlated with the diversity of function of the structures which are required for effecting suction.

The groups of muscles are as follows:—

#### (1) *The Divaricators.* (Text-fig. 2, D.M.)

These muscles are attached to the upper wall of the pharynx; the mode of their attachment varying in different parts of the head. In the clypeal region they are attached to the ligament of the operculum (the upper wall of the pharynx); while in the epicranium they are attached to the pharynx directly.

I find that these muscles are strengthened by chitinous rods comparable perhaps to the tendons in the muscles of the vertebrates (text-fig. 2).

These muscles fall into two groups, according to the mode of their attachment and arrangement:—

(a) The fan- or feather-shaped muscles. (Text-figs. 14-21).—These are arranged like barbs on a feather vein or rachis, alternating with one another on either side. This arrangement begins in the clypeal region and gradually disappears posteriorly. They are attached to the opercular ligament, which is the continuation of the soft chitin lining the operculum. In the clypeo-labral region, *i. e.*, in the region where the gustatory organs are situated, the ligament passes between those organs to give attachment to these muscles. The gustatory organs consist of four lobes arranged in pairs on either side of the dorsal wall of the pharynx. (Text-figs. 27, 28.)

The fan-shaped arrangement is found in the region where there is a great amount of work done; the work being to produce a vacuum sufficiently powerful to suck in the sap which is being accumulated in the pharyngeal duct. This vacuum is produced by contractions of these muscles, the operculum being pulled out of the ventral wall of the pharynx. The arrangement described gives a large surface for the attachment of the muscles.

(b) The strap-shaped muscles.—These are found in the epicranial region, where they are directly attached to the upper wall of the pharynx, which has here lost its character of operculum. Here its ventral wall also loses its chitin, and the whole structure is gradually transformed into the soft and thin oesophagus which is no longer concerned with suction. These muscles are attached to the dorsal wall of the head in the median line.

The divaricators occupy a large area in the head, beginning in the clypeo-labral region and ending in the anterior part of the epicranium.

(2) *The Pump muscles, or Aspirators.* (Text-figs. 2, 4, 5, 7, 17, etc. P.M.)

These are next to the divaricators in order of importance, though they do not occupy such a large space. They are very compact and powerful, as may be seen from the mode of their arrangement and attachment. They lie below the pharynx in the median line, but they diverge on either side towards the posterior arms of the tentorium, to the ventral surface of which they are fused. At the other end they are attached to the handle of the piston of the pump.

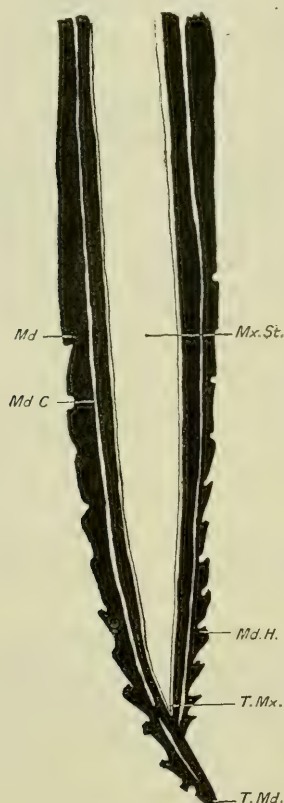
When they contract they pull out the piston of the pump, the posterior arms of the tentorium being very strong and rigid at the sides. This pulling out cannot be an easy thing, small as the pump is, because the posterior wall, of which the piston forms a part, is made of thick, unyielding, though elastic, chitin, the resistance of which must be enormous. Hence their disproportionate size and the mode of their attachment can easily be understood.

(3) *The Protractors of the Stylets.* (Text-fig. 6, Mx.P., Md.P.)

(a) *The Protractors of the Mandibles.* (Text-figs. 16, 17, 19, etc., Md.P.)

These muscles are attached at one end to the distal ends of the levers of the mandibles (and not to the mandibles themselves), and at the other to the clypeal folds, which run into the head to a considerable distance. They are short and thick, and run obliquely

Text-figure 23.



*Lygus pabulinus.*

Tips of the stylets, showing the recurved hooks of the mandibles and smoothness of the maxillary stylets. Immersion-lens & Oc. 4.

For explanation of the lettering see p. 693.

from one to the other. Their attachment at the distal ends of the levers makes it easy to pull the latter down with the mandibles. There is no hinge-like device at the bases of the levers, but when they are pulled down they do not, I think, regain their normal

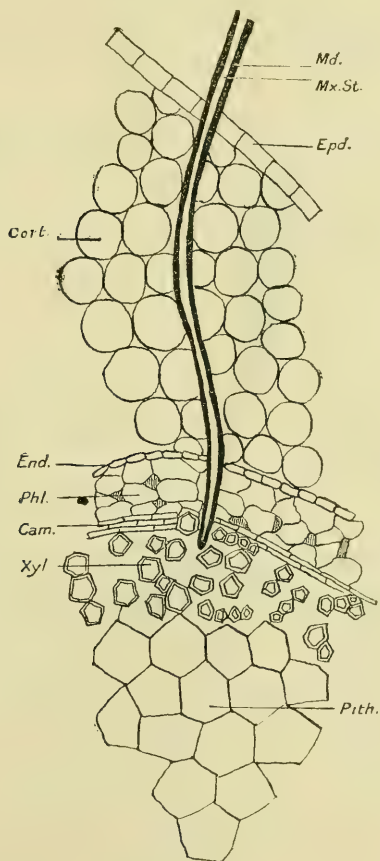
positions by their own elasticity alone or that of the side-walls of the head. They are brought to their original positions by the antagonistic muscles.

The protractors are the chief agents in bringing about protrusion of the mandibles.

(b) The Protractors of the Maxillæ. (Text-figs. 16, 19, 21, etc., Mx.P.)

They are attached at one end to the sides of the maxillary

Text-figure 24.



*Lygus pabulinus*.

Hand section, showing the stylets in the plant-tissue. Stained with saturated picric in 90 per cent. alcohol. Ob. 3 & Oc. 4.

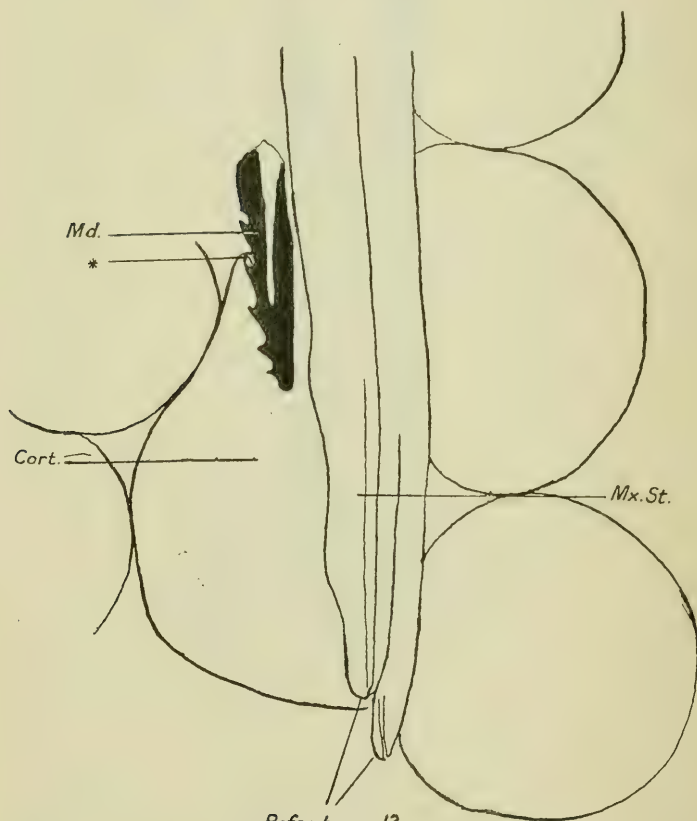
For explanation of the lettering see p. 693.

stylets (and not to the levers), and at the other to the maxillary sclerite. It has been shown above that the latter is nothing but the maxillary plate, the second half of the embryonic maxilla.

(4) *The Retractors of the Stylets.* (Text-figs. 16, 19, 21.)

These are attached to the sides of the mandibles and the maxillary stylets just below the retort-shaped organs at one end, and to the posterior walls of the head at the other. The stylets show peg-shaped structures for the attachment of the muscles

Text-figure 25.



Refer to p.p. 12.

*Lygus pabulinus.*

Transverse section of a petiole, showing the maxillary stylets forward and the mandibles behind, one of the hooks (\*) of the latter being attached to the cellular wall. Immersion lens & Oc. 4.

For explanation of the lettering see p. 693.

(text-fig. 6), which are spread at their other ends over a large part of the posterior wall of the head.

The retractors of the mandibles consist of two groups which pass above and below the optic nerve (text-fig. 5).

(5) *The Maxillo-mandibular Muscles.* (Text-figs. 20, 21, Mx. Md.M.)

These run from the mandibular levers to the levers of the maxillary stylets on either side. It will be remembered that the mandibles and the maxillary stylets do not lie at the same level, one being above the other, and at the same time the maxillary stylets project further back into the head than the mandibles. In the normal position the tips of the mandibles and the maxillary stylets are level, and in this position they are thrust into the plant-tissue.

When these muscles contract, they pull in the mandibles and push forward the maxillary stylets a little. Thus there is no hindrance to suction by the maxillæ, as they are free from the mandibles. At the same time the mandibles get themselves fixed into the cellular walls by means of their recurved hooks and thus steady the maxillæ for suction, as the latter are firmly attached to the former by the interlocking device. Thus these muscles play a useful part in the mechanism of suction.

(6) *The Antagonistic Muscles.* (Text-figs. 5, 6, 20, A.M.)

These muscles are attached to the mandibular levers at one end and to the postero-dorsal wall of the head at the other. They are called antagonistic because they oppose the protractors of the mandibles in their action, inasmuch as they bring the levers back to their normal positions. They are very important, as there is no other device to effect this readjustment.

They have nothing to do with the pharynx, as Bugnion and Popoff (4) seem to think, who describe these muscles as "Antagonistique ou Abaisseur du Pharynx." The description that they are attached to "une lame horizontale rattachée au Pharynx par une expansion," is absolutely inaccurate. This horizontal blade (lame) is nothing but the mandibular lever, which has nothing to do with the pharynx, but which is attached to the mandible. "La lame horizontale tendant à effectuer un mouvement de bascule, l'effet de l'antagoniste doit être d'abaisser le pharynx ou tout au moins de le maintenir en place au moment où le dilateur entre en action." "La fonction du muscle antagoniste est de maintenir l'appareil en place." With due respect to these authors, I think that their description is absolutely beside the mark. These muscles have nothing to do with the pharynx. Wedde, however, holds that there is no need for such antagonistic muscles of Bugnion. He says, "Antagoniste für die Schlundmuskulature sind nicht vorhanden, es wirken als solche die höchst elastischen chitintteile des Pharynx selbst."

Wedde, however, thinks that they are the clypeal muscles, which have nothing to do with the mandibular levers, but which are attached to them. He does not seem to have understood the nature of the "horizontal bar," which is nothing less than the mandibular lever.

(7) *The Constrictors or Circular Muscles.* (Text-figs. 2, 7, Con.M.)

These muscles are found in the œsophageal region. They lie outside the external epithelium of the œsophagus. Their contraction and relaxation produce a kind of peristalsis which forces the sap onward into the stomach. Bugnion (4) says, "quant au constricteur, son rôle doit être de pousser dans l'œsophage le liquide absorbé."

(8) *The Valvular Muscles.* (Text-fig. 7, V.M.)

They are short and thin and extend from the base of the cardiac valve in the œsophagus to the posterior arms of the tentorium, to both of which they are attached. When they contract, the sides of the valve are pulled apart, the valve thus opens, the lumen of the œsophagus widens, and the sap, which is under a great pressure behind, is forced onward into the stomach. I cannot find them described by any previous writer.

(9) *The Labial Muscles.* (Text-figs. 2, 16, Lb.M.)

These are found in the first segment of the labium, and seem to be important in increasing the amount of protrusion of the stylets by bending the labium. They are attached at one end to the supporting struts (buccal folds) on either side of the pump-cylinder, and at the other to the first joint of the labium, which is swollen, and thus offers a large area for the attachment of these muscles.

It will be remembered that the proboscis bends upon itself, the bending occurring at the first joint. The deeper the required plant-tissue lies, the greater is the bending of the proboscis. There must be some device to effect this bending, and such a device is supplied by these labial muscles. When the muscles contract, the first joint is pulled up and acts as a hinge—the proboscis bending on it.

According to Geise, Wedde, and Nietzsche they are elevators and depressors of the labium. In the insect under consideration no muscles are found that could possibly function in this way.

(10) *The Muscles of the Antennæ.*

As these have nothing to do with suction, they will not be described.

N.B.—Wedde has described two pairs of protractor muscles of the maxillary stylets, one of which is attached to the maxillary

sclerite, the other passing below the pharynx. It seems that the latter pair does not represent the protractors but the pump muscles.

### THE PHARYNX, OR SCHLUNDKOPF. (Text-fig. 2.)

This is one of the interesting and characteristic organs of the Rhynchota. In transverse sections it resembles roughly the pharynx of a sucking Dipterous insect (Nuttall and Shipley (40)). There are, no doubt, some differences in each case, but the general plan is the same throughout. In all these cases suction is effected by the production of a partial vacuum inside the pharynx, in order to fill which the sap or blood flows up the proboscis.

The pharynx is a long, chitinous organ with a narrow lumen. Its structure varies in different regions of the head, and therefore it is proper to treat its several parts under different names.

There are three distinct modifications in different regions:—

(i.) The Pharyngeal duct, in the clypeal region, where the operculum as such does not exist, and the whole structure—here formed from the lower wall of the pharynx alone—forms one round duct which opens into the suction-canal. (Text-figs. 11–13, Ph.D.)

(ii.) The Pharynx proper, in the clypeal region and the anterior part of the epicranium, where its upper wall, as the operculum, is clearly distinguishable. (Text-figs. 14–21, Ph.)

(iii.) The Œsophagus, in the epicranial region, where the walls of the pharynx are soft, and the operculum as such disappears. (Text-figs. 2, 22, Œs.)

#### (i.) *The Pharyngeal duct.*

This is the continuation of the pharynx proper into the labral region where it opens into the suction-canal. It is the modified pharynx, the modification consisting in a gradual elimination of the epipharynx from the upper wall of the pharyngeal duct, from behind forward. The lower wall at the same time gradually gets thinner and more rounded and ultimately forms a duct by itself. The divaricator muscles of the pharynx have disappeared with the operculum. At the place where the pharynx ends and the duct begins there are found the gustatory organs communicating with the lumen of the duct through the cribriform plate (text fig. 26, G.Or., Cri.Pl.) In this region the hypopharynx (text-figs. 13, 14, Hyp.) is well developed, forming a folded structure supporting the maxillary stylets and the mandibles laterally, and enclosing the efferent salivary duct underneath. It supports the pharyngeal duct in the region where it has no other support, neither that of the body of the tentorium nor that of the tentorial arms. Anteriorly the hypopharynx becomes smaller and smaller and less folded. It brings the efferent salivary and the pharyngeal ducts nearer to each other (text-figs. 11–13, Ph.D., E.S.D.), and finally

disappears, leaving free these ducts, which open ultimately into the suction- and the ejection-canals respectively (text-figs. 10 A and 10 B).

The pharyngeal duct runs to a considerable distance into the suction-canal before it ends. The importance of this arrangement lies in the fact that it makes allowance for the movements—up and down—of the maxillary stylets. Had this duct run to a shorter distance into the suction-canal, there would have been some danger of its slipping out when the stylets were pushed down to their natural limit of extension.

(ii.) *The Pharynx proper.*

This is found to begin in the clypeal region behind the clypeal folds and to end in the anterior part of the epicranium. It is bent anteriorly, and its bend corresponds to that of the head. Posteriorly it is straight and runs directly into the œsophagus. It is different in structure from the pharyngeal duct and from the œsophagus. It is the chief organ of suction in the insect.

When seen in transverse section it consists of two distinct parts: the ventral part and the dorsal. The first may be called the “V” and the second the operculum. They are different in shape and structure. (Text-figs. 14-21.)

(a) *The “V” or ventral wall of the pharynx (V.Ph.).*—This is more or less V-shaped in section, its angle being considerably drawn out in some places. In the anterior and the posterior regions this angle gets rounder, and the characteristic form of the “V” is lost, as in the pharyngeal duct and the œsophagus. In the clypeal region, where the pharynx proper begins, the arms of the “V” are elongated and fused with the clypeal folds running into the head (text-figs. 16, 17, 19, Clp.F.). Thus it is dorsally supported by these folds.

In the same region, moreover, the “V” is wedged ventrally into the body of the tentorium and retained there by the connective tissue, its ventral shape corresponding exactly to the dorsal groove in the latter (text-figs. 17, 19, T.B., V.Ph.). The dorsal arms of the tentorium run parallel with those of the “V” and support it laterally. It is this part of the pharynx which needs support because it is here that the sucking force is applied.

The posterior arms of the tentorium as they run backward also support the pharynx to some extent, but they soon diverge laterally and leave it (text-fig. 20, P.A.).

The “V” is of thick chitin which, however, becomes thin and soft anteriorly and posteriorly in the pharyngeal duct and the œsophagus.

(b) *The Operculum or dorsal wall of the pharynx (Op.).*—Its structure is entirely different from that of the “V”. It is closely apposed to the “V” in its normal position, which is regained by its own elasticity, and from which it is pulled by contraction of the divaricator (pharyngeal) muscles. It is obvious that there

is no space left in the lumen of the pharynx when the operculum is in the normal position, but a strong vacuum is produced in it when it is pulled out.

It is lined with a thin and soft chitin which is continued dorsally into a ligament to which the divaricators are attached.

Posteriorly it loses its character as an operculum (text-fig. 22); it is no longer introversible though it remains flexible. The "V" and the operculum form together, in this posterior part, one structure, which is more or less circular and is continued in the œsophagus. In this region the muscles are directly attached to it instead of to the ligament. As it passes anteriorly into the pharyngeal duct it also loses its flexibility and introversibility. It fuses with the epipharynx (labrum) which now covers the ventral wall, and the muscles are again no longer attached to it. Thus in both directions (anteriorly and posteriorly) the pharynx proper loses its character as such, both in respect of the "V" and the operculum.

There is a hinge-like fold of chitin upon which the operculum turns inside out. It will be understood from the figure (text-fig. 20).

The supports of the pharynx proper are:—

- (i.) The hypopharynx.
- (ii.) The clypeal folds.
- (iii.) The body of the tentorium with its dorsal arms.
- (iv.) The posterior arms of the tentorium.

All these supports make the "V" immovably and firmly fixed in its proper place, while the operculum remains all the time flexible and introversible.

The function of the pharynx proper is very important since it is the chief organ of suction. The pharyngeal duct cannot start suction as there are no muscles attached to its dorsal wall, which is no longer introversible; as explained above the operculum in its normal position is closely apposed to the "V," and thus there is no empty space between them. The muscles contract, the operculum is pulled out, and a strong vacuum is produced. To fill it up, the sap, which is now present in the pharyngeal duct, is sucked into it.

### (iii.) *The Œsophagus.*

There is no sharp external demarcation between the pharynx proper and the œsophagus, the transition is gradual, the "V" and the operculum losing their characteristic structures. In some other species there is, at the entrance to the œsophagus, a constriction, which is due to the fact that the thick chitin of the pharynx proper ends suddenly where the œsophagus begins. The nerve-mass, consisting of the supra-œsophageal ganglia, the lateral commissures, and the sub-œsophageal ganglia, surrounds the œsophagus, which then opens straight into the stomach through the cardiac valve.

The œsophagus is lined with the layers of an epithelium, and, innermost of all, a soft chitin, which disappears posteriorly: from this point, the outer layer of the œsophagus is generally one cell thick, the cells being small. The inner layer consists of elongated cells which have vacuoles in them, and which are greatly developed in the stomach. Outside the outer epithelial layer are found the constrictor and the valvular muscles. (Text-fig. 2, Con.M., V.M.)

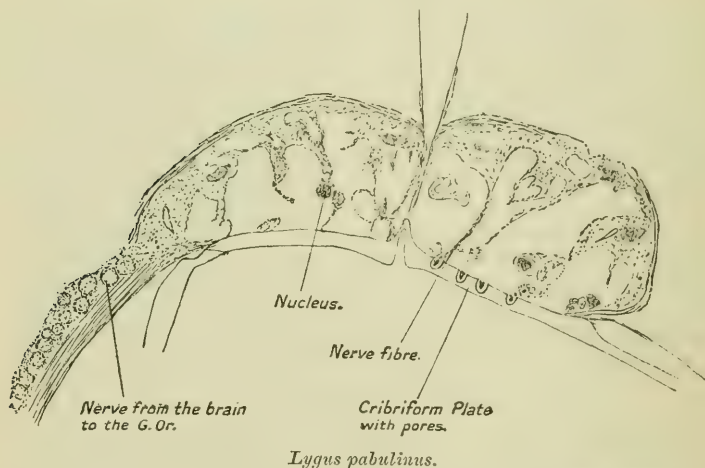
*The Cardiac Valve* (text-figs. 2, 7, C.V.)—This is very short, and it seems that its position in the œsophagus varies in different insects. In *Schizoneura lanigera* it is present at the end of the œsophagus (Davidson (9)), but in *Lygus* the valve is in its middle. It is formed by the doubling of a part of the œsophagus upon itself. The valvular muscles are attached to the base of the valve. It remains closed in the normal position until the muscles contract, when it is opened.

It prevents any return-flow of the sap from the stomach into the œsophagus.

#### THE GUSTATORY ORGANS. (Text-figs. 26–28.)

That these are a specialised part of the supracœsophageal ganglia is proved beyond doubt. They are situated upon the

Text-figure 26.



*Lygus pabulinus.*  
Longitudinal section, showing the histological structures of the gustatory organs with the cribriform plate, etc. Ob. 6 & Oc. 4.

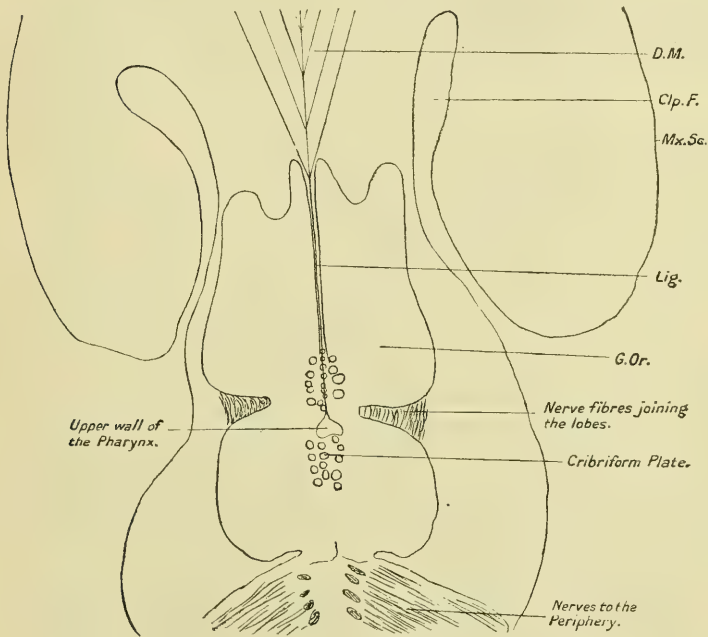
For explanation of the lettering see p. 693.

operculum in the clypeo-labral region. There is a nerve running from the brain to these organs on the upper wall of the pharynx. Their histological structures, though specialised, are similar to those of the brain.

In vertical sections, they show four lobes, arranged in pairs on either side of the operculum. The ligament passes through them to give attachment to the divaricators (text-figs. 27, 28, G.Or., Lig.). There are nerve-fibres running into the pharynx, and also from one lobe to the other. There are, moreover, small nerves issuing from them and distributing themselves over the epipharyngeal region.

*The Cribriform Plate* (text - figs. 27, 28, Cri.Pl.).— The chitinous plate upon which these organs are situated is perforated, and through it the nerve-fibres communicate outward

Text-figure 27.

*Lygus pabulinus.*

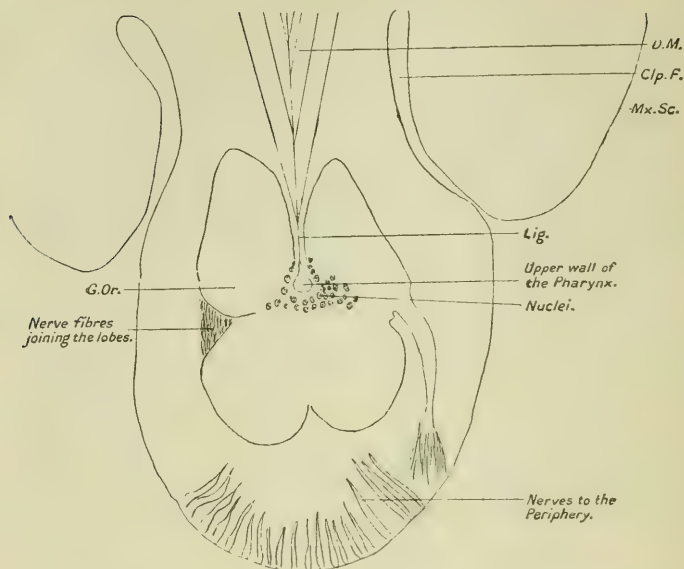
Vertical section of the gustatory organs with the cribriform plate, showing nerves passing to the periphery, etc. Ob. 6 & Oc. 4.

For explanation of the lettering see p. 693.

with the lumen of the pharynx. This cribriform plate seems to be analogous with that found in the mammals, in which the olfactory nerve-fibres pass through its pores to the olfactory sense-organ.

These organs seem to be gustatory. Their function seems to be to taste the sap as it comes into the pharyngeal duct.

Text-figure 28.

*Lygus pabulinus.*

Vertical section of the gustatory organs with the cribriform plate, showing nerves passing to the periphery, etc. Ob. 6 & Oc. 4.

For explanation of the lettering see p. 693.

### THE PUMP-APPARATUS, OR WANZEN-SPRITZE.

This apparatus is one of the characteristic structures of the Rhynchota, and has been described, though not in detail, by many writers. It was first discovered by Landois (28) in *Cimex*, and described later on by Wedde (46), in some detail, in *Pyrrhocoris*.

It has been found in almost all rhynchotous forms except the Anoplura. Wedde has attached so much importance to it as to divide the Hemiptera into two groups: (i.) Rhynchota setifera—with the pump-apparatus, and (ii.) Pediculidæ—without it. It is possible that, in the Pediculidæ, it may have escaped the notice of investigators, since it must be very minute. I am the more encouraged in this belief because Grove (16) says that the pump-apparatus is not found in *Siphonophora rosarum* (a tolerably big form), though he has figured it in his drawings (fig. 7 *loc. cit.*). He further says, "In exactly the same position in the small pointed under-lip . . . which closes the mouth on its posterior margin, where the above authors have described the salivary pump, is a small U-shaped rod of solid chitin." This small rod of solid chitin is nothing but the pump-cylinder.

The pump may conveniently be divided into four parts for description:—

- (i.) The pump-cylinder with the pump-chamber and the pump-stem. (Text-figs. 2, 3, 7, 14, 15, 16, P.Cy., P.Ch., P.St.)
- (ii.) The piston with the handle. (Text-figs. 15, 16; Pi., Pi.H.)
- (iii.) The efferent salivary duct. (Text-figs. 3, 10–15, E.S.D.)
- (iv.) The afferent salivary duct. (Text-figs. 2, 3, 16, etc. A.S.D.)

(i.) *The pump-cylinder with the pump-chamber and the pump-stem.*—The pump-chamber is more or less oval in section, and its thick and rigid chitinous lining (constituting the pump-cylinder) consists of two walls, an anterior and a posterior, which differ from one another in structure and shape, though there is no discontinuity of chitin between them.

(a) The anterior wall (A.W.P.). This is roughly semicircular in section. Its middle portion is drawn out anteriorly into a thickened solid process, which fuses with the hypopharynx, and this thick portion of the pump is known as the pump-stem (text-fig. 3, P.St.), which is perforated by the efferent salivary duct. The chitin of the anterior wall is thick, elastic, and incompressible. It gets, however, thinner laterally, and is continued into the posterior wall dorsally; but ventrally it lines the entrance of the afferent salivary duct.

(b) The posterior wall. This is apposed to the anterior wall in the normal position. Its middle portion is swollen and is called the piston. This is continued backward to form the handle. Its chitinous lining is elastic, introversible, and can be retracted from the anterior wall to a certain extent when the pump muscles act. These muscles have already been described above.

(c) The pump-chamber. The space between the walls, anterior and posterior, of the pump-cylinder constitutes the pump-chamber. In the normal position, when the posterior wall is apposed to the anterior, its capacity is reduced to a minimum. Introversion, of course, increases this capacity. Into the chamber opens antero-ventrally the afferent salivary duct, and from it issues antero-dorsally the efferent salivary duct, which latter finds its way out through the pump-stem to open into the ejection-canal of the maxillæ. (Text-figs. 3, 10 B., P.Ch.)

(d) Attachment. The pump-cylinder is attached by connective tissue to the body of the tentorium, which is situated just above it; the ventral groove of the tentorium corresponds exactly to the dorsal semicircular contour of the pump-cylinder. The attachment of the cylinder to the hypopharynx through the pump-stem has already been mentioned under (a).

(ii.) *The piston with the handle.*—The middle portion of the posterior wall is swollen and continued backward to a considerable

distance as a solid rod of chitin. To this the pump muscles are attached. This structure constitutes the piston and the handle, the swollen portion being the piston and the backward continuation the handle. The latter is flattened dorso-ventrally.

(iii.) *The efferent salivary duct.*—This is a long and narrow duct, issuing antero-dorsally from the pump-chamber. It has a very narrow lumen and runs through the pump-stem and perforates the hypopharynx before it opens anteriorly into the ejection-canal. It has been shown above that the pharyngeal duct also runs through the same region of the hypopharynx on its way to the suction-canal. These ducts are thus brought together and connected with one another by the hypopharynx. It is the only connection between them; otherwise they are distinct from each other. They do not communicate with one another. And yet there are many misrepresentations about it. Many of the previous writers are very doubtful of the facts, and do not seem to know whether the efferent duct runs straight into the ejection-canal or the labial groove, or opens into the pharyngeal duct. Muir and Kershaw (22) write: "The syringe or salivary pump . . . opens on the basal part of the labium beneath the hypopharynx." This statement is too vague to be criticised. According to them, it seems that the efferent salivary duct opens into the labial groove. The same mistake has been made by Grove (16), and is also found in many text-books. The efferent salivary duct opens neither into the labial groove nor into the pharyngeal duct, but, on the contrary, runs straight into the ejection-canal and opens there. In short, the ducts, pharyngeal and efferent salivary, are separate from one another and open into the suction- and ejection-canals of the maxillary stylets respectively. (Text-fig. 10, Su.C., E.C.)

The efferent duct is supported by

- (i.) The pump-stem, and
- (ii.) The hypopharynx.

It runs a considerable distance into the ejection-canal before it ends. This prevents its slipping out of the canal when the maxillæ are pushed down by their protractors. (Cf. pharyngeal duct.)

(iv.) *The afferent salivary duct.*—The two salivary ducts issuing from the reservoirs on either side come together in the head and form the afferent or common salivary duct under the brain. This afferent duct is seen, in median longitudinal sections, running underneath the pump-cylinder and opening antero-ventrally into the pump-chamber. It has a lumen bigger than that of the efferent salivary duct, and its walls are flexible and elastic. There is not a trace of a valve at its entrance into the pump-chamber.

*The salivary ducts* (text-fig. 7, S.D.)—There are two salivary

ducts, one on each side, issuing from the salivary reservoirs in the thoracic region. They are narrow and long, and run straight into the head, where they join together and form the common salivary duct. They are always full of secretion, and as they are thin and elastic, their walls are distended. The secretion is therefore under pressure.

### *The Function of the Pump.*

The structures of the pump, described above, will show that it is used to force the salivary secretion forward into the efferent salivary duct and thence into the ejection-canal of the maxillary stylets. Hence it has been called a force-pump.

The ejection-canal pours the secretion straight into a wound in a leaf made by the stylets. The secretion does not leak out since the canal is air-tight, which will be seen from cross-sections. The shape of the cylinder in different species depends upon the degree of force required to drive the secretion through the efferent duct. The more minute this duct the more cylindrical is the pump: the return-stroke of the posterior wall is more powerful in proportion to the force required to pull out the piston. The posterior wall of the pump may be compared to a bow.

In the normal position the posterior wall is apposed to the anterior, and the capacity of the chamber is reduced to a minimum. When the pump muscles, which are attached to the handle, contract, the piston is pulled out and with it the posterior wall. The capacity of the chamber slowly increases and a partial vacuum is produced. Now, either the secretion from the efferent duct or that from the afferent duct must flow into the chamber to fill up this vacuum. The former case is impossible, as the efferent duct is very short and empties itself into the ejection-canal as soon as it is charged with the secretion, and when empty its lumen would tend to collapse owing to the thinness of its walls. On the other hand, the salivary ducts are always full of secretion under pressure, and their walls are always distended by their contents. As soon, then, as a vacuum is produced in the chamber, the secretion in the afferent duct flows forward into it. Thus, every time the muscles contract and the vacuum is produced, fresh secretion from the reservoirs flows into the pump-chamber.

When the muscles relax, the posterior wall of the cylinder begins to return to its former position, the return-stroke being effected by its own elasticity. The fluid in the chamber is gradually being compressed, and is forced along the line of least resistance, which lies through the efferent salivary duct. This duct is empty now, while the afferent duct is full of secretion under pressure. The secretion therefore must flow into the efferent duct. The space of the chamber is gradually being reduced, and the entrance of the afferent duct into the chamber

is closed when that critical point is reached at which the pressure inside the chamber becomes higher than that in the afferent duct. This closure is effected by the posterior wall itself, which slides over and closes the entrance to the duct. Thus there is no necessity for a valve, and the saliva, once in the chamber, never flows back into the afferent duct.

To sum up:—

- (i.) The pump is a force-pump.
- (ii.) The return-stroke of the posterior wall is effected by its own elasticity, when it has been pulled from the anterior wall by the pump muscles.
- (iii.) The efferent salivary duct is short and empties itself into the ejection-canal as soon as it is charged with secretion. It is therefore empty when the return-stroke begins.
- (iv.) The afferent salivary duct is always full of secretion, which is always under pressure. It is longer than the efferent duct.
- (v.) No valve is required at the mouth of the afferent duct into the chamber; nor are there any muscles to open it. Its opening and closing are automatic.

#### THE MECHANISM OF SUCTION.

The functions of the different parts concerned in suction have now been described under their respective headings. The present section gives a connected account of the mechanism, summarising, at the same time, what has been said above. The following is a picture of the mechanism as it might be imagined from the arrangement of the different structures described.

The mechanism consists of many structures in the dead co-ordinated with one another, from the piercing of the epidermis of a leaf by the stylets to the digestion of the sap in the stomach.

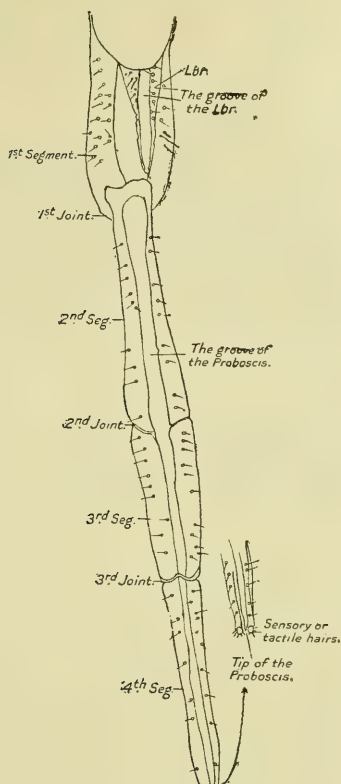
##### (1) The stylets inside a leaf.

The insect begins to feel the surface of a leaf with the sensory hairs at the tip of the proboscis (text-fig. 29). It is trying to find a good place for piercing. When it is found, the proboscis is applied to it, the stylets are driven forward, the protractors contract, and the epidermal layer is pierced, however thick it may be.

##### (2) The bending of the proboscis.

Once in, the stylets are pushed down into the tissue by direct mechanical force, *i.e.* by the bending of the proboscis. This feature has already been alluded to. It increases artificially the protrusion of the stylets and enables them to reach the tissue which contains food. It seems that the insect is not confined to any particular plant-tissues. The stylets may be found in the xylem, the phloem, or in the cortex which contains food-substances (text-figs. 24, 25).

Text-figure 29.

*Lygus pabulinus*.

Mount, showing the labium macerated in potash and stained with saturated picricin, 90 per cent. alc.

### (3) Injection of Saliva into the wound.

When the stylets reach the particular tissues, the maxillo-mandibular muscles begin to act. Their function has already been dealt with. The mandibles, when they are pulled in by these muscles, get fixed into the cellular walls by means of their recurved hooks (text-fig. 25). The maxillary stylets are made steady in their action by the mandibles because of their interlocking arrangement.

Before the sap is sucked through the suction-canal, it seems that saliva is injected into the wound made by the stylets. It is possible that the saliva, by being mixed with the sap, may trans-

form starch into sugar and thus help its digestion. Plateau (41) has proved that the saliva of insects has this effect. It is doubtful whether the sap is coagulated by exposure to air, but if so, the saliva may prevent its coagulation. A third possibility is that saliva may make the sap less viscid.

#### (4) Turgidity of the Cells.

This may be important indirectly in forcing the sap mixed with saliva into the suction-canal of the maxillary stylets. The cells of a tissue are always turgid and their walls are stretched to their utmost capacity. They collapse if pricked, and squirt out the sap with some force. The maxillary stylets pierce the cells, the sap of which may thus be forced into the empty suction-canal, since the other canal is full of the salivary secretion. I attach no great weight to this possible factor in suction.

#### (5) Capillarity.

This factor may now come into action, and by its means the sap would begin to ascend in the suction-canal if this were open at the top. The sap reaches the pharyngeal duct, which hangs into the suction-canal, and is thus immersed in the sap.

#### (6) Suction.

The divaricators of the pharynx begin to act. Those of the anterior part of the clypeus contract first. The operculum is pulled out and a vacuum is formed between it and the "V." The sap is sucked into the pharynx from the pharyngeal duct. The muscles relax, and the operculum regains its former position. Meanwhile the muscles lying posteriorly contract, the operculum is pulled out, and the sap is forced onwards. The muscles lying still more posteriorly, do the same thing, and the same process is repeated. Thus there is a wave of contraction of muscles passing backwards, and the sap is continuously forced on towards the stomach. It is prevented from flowing back, because there is no empty space behind, since the operculum regains its normal position with relaxation of the anterior muscles.

Thus, in the pharynx there are two complementary factors which force the sap onwards towards the oesophagus:—

- (i.) The vacuum produced by the raising of the operculum.
- (ii.) Elasticity of the operculum, which enables it to regain its normal position.

#### (7) The Oesophagus.

The sap is forced into the oesophagus, the walls of which are soft and flexible and have attached to them the constrictor muscles. As the sap distends the walls, the muscles contract, and a peristalsis is produced which forces the sap onwards towards the cardiac valve.

## (8) The Cardiac Valve.

The valvular muscles contract, the valve opens, and the sap is forced into the stomach.

## (9) The Stomach.

This is a bag-like structure and stores the sap.

To sum up :—

There are the following factors at work :—

- (i.) Capillarity in the suction-canal, helped by turgidity of the cells.
- (ii.) Suction produced by the vacuum through the raising of the operculum.
- (iii.) The peristalsis in the œsophagus by means of the constrictors.
- (iv.) The valvular action, which prevents the sap from flowing back into the œsophagus from the stomach.

The pharyngeal duct hangs into the suction-canal and is immersed in the sap. A question arises whether it is possible for the sap to avoid the duct and flow into the body-cavity from the suction-canal. The sap cannot do so because (i.) there is no difference of pressure to force the sap into the body-cavity, and because (ii.) there is active suction through the pharyngeal duct.

Another important thing for suction is that the suction- and ejection-canals must be separate and distinct from each other. The least intercommunication will stop the whole mechanism. Also one canal cannot serve two contradictory purposes—one of sucking and the other of ejecting saliva. The whole mechanism, therefore, depends upon the presence of the two canals. (But, curiously enough, the Bed-bug, *Cimex*, is stated to present such an anomalous case. It has only one canal for sucking the blood and ejecting the saliva as well. Recently it has been described by Dr. Max Braun (1): "In shape the maxillæ resemble two gutters, the concave surfaces of which face one another and so form a tube. This serves to conduct the blood from the wound into the pharynx and also saliva into the wound. In other Hemiptera food and saliva are conveyed by two distinct channels formed by the longitudinal ridge which runs down the groove of each maxilla, dividing it into two parts." This is not the case actually, as I hope shortly to show by figuring sections of its mouth-parts.)

*Damage to the Plant.*

That *Lygus pabulinus* does some damage to potato plants has been conclusively proved by the elaborate experiments of Prof. Lefroy, of the Imperial College of Science, and Mr. Horne.

It is sufficient to say here that the insect drills into the leaves holes which are bordered afterwards by brown rims. It does not

come within the scope of this paper to deal with the pathological effects due to the insect-bites; but the way in which these holes are drilled is described below.

The structure and the shape of the stylets have been described above. The tips of the maxillary stylets are smooth and lancet-shaped, but those of the mandibles are deeply serrated (text-fig. 23). The tip of the proboscis is covered with stiff hairs and is blunt. How the stylets work inside the plant-tissue has been described above. The insect is found on the same place for hours at a stretch. It withdraws its stylets every few minutes from the plant-tissues and thrusts them in again. This process is repeated many times. Since the mandibles can only be withdrawn by tearing the cells each time they are taken out with their recurved hooks (text-fig. 25), and as this process is repeated many times, a big area is ultimately macerated and a hole is formed there afterwards.

It was held by many writers—Dr. Riley being one of them—that the Heteroptera made holes with the proboscis, the Homoptera with the stylets. This view is absolutely inaccurate, since it is found that the proboscis is incapable of drilling holes, its tip being too thick and blunt to pierce the epidermis. Sections of plants taken with the stylets *in situ* show that the stylets enter the tissues, the proboscis itself remaining outside, as described above.

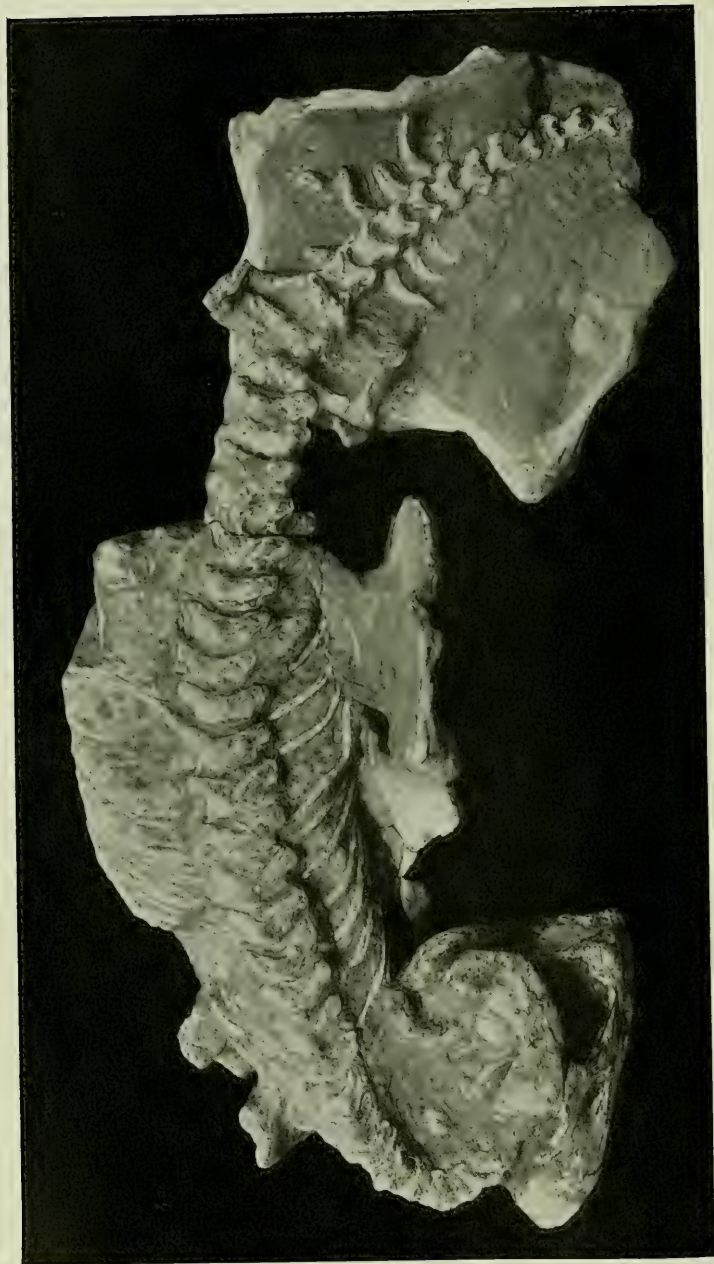
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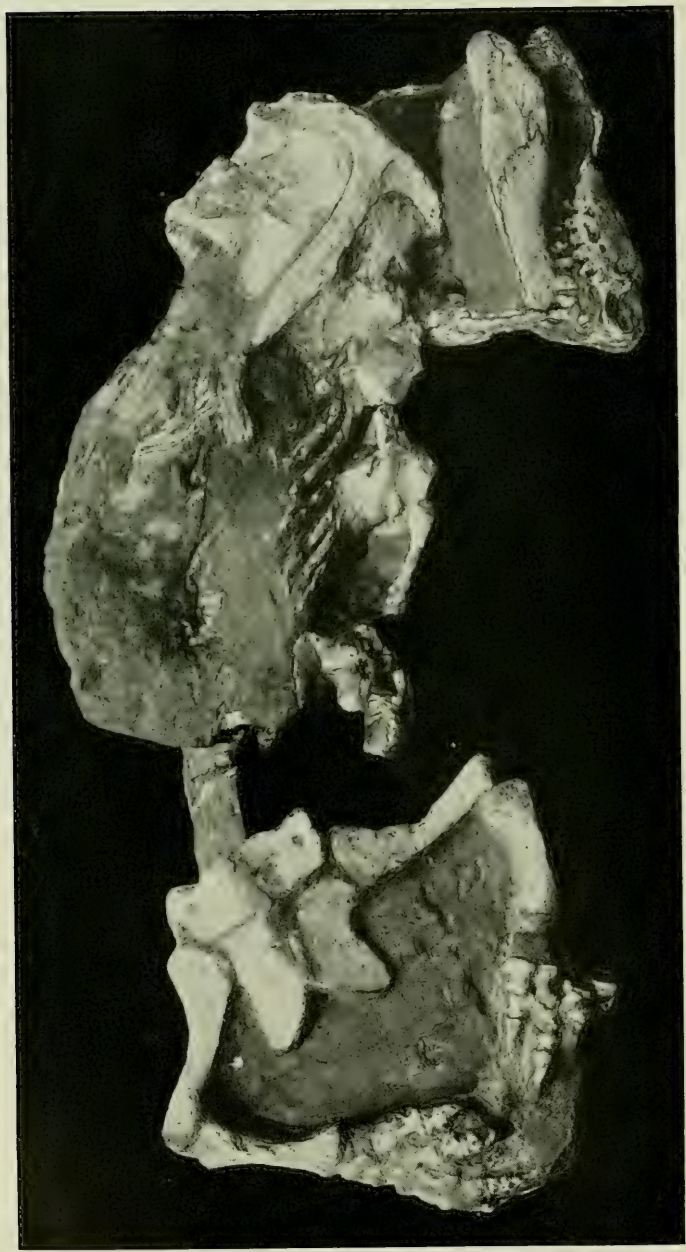




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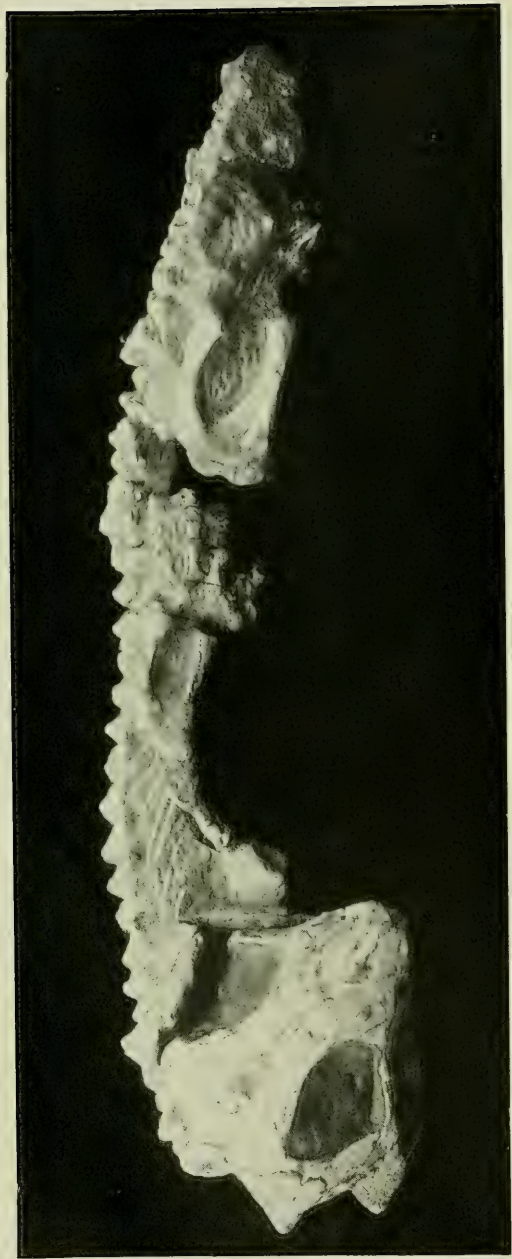




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41. *Procolophon trigoniceps*, a Cotylosaurian Reptile from South Africa. By D. M. S. WATSON, M.Sc., F.Z.S., Lecturer in Vertebrate Palæontology in University College, London.

[Received May 18, 1914: Read June 9, 1914.]

(Plates I.-III.\* and Text-figures 1-5.)

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The little reptile *Procolophon* has long been known, and the work of Owen, Seeley, Woodward, and Broom has made us acquainted with much of its structure. During my visit to South Africa, I was fortunate enough to collect in the original locality, Donnybrook, Upper Zwaart Kei, Dist. Queenstown, a nearly complete skeleton (hereafter referred to as the female skeleton) and several skulls and fragments. On the farm, Haslop Hill, which lies about fifteen miles north of Donnybrook, I obtained another almost absolutely complete and very well-preserved skeleton, which I shall call the male skeleton.

This material, together with that in the British Museum, is perhaps the most extensive in existence for the study of any early reptile, and gives knowledge of almost every detail of the structure.

*Skull.*—The general structure of the skull has long been known, but it is now possible to describe the basis cranii and brain-case in detail.

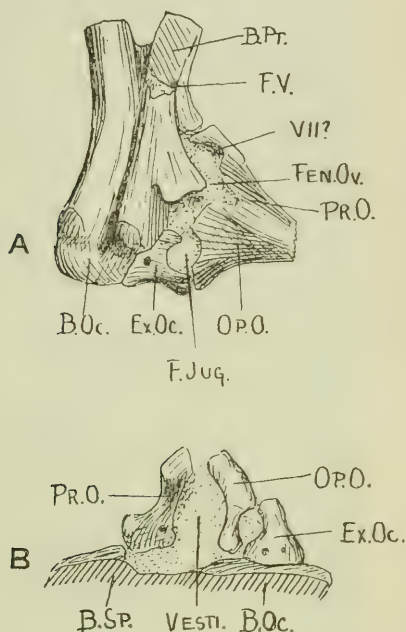
The basioccipital is a comparatively small bone whose posterior end is formed by the transversely widened condyle, which is rounded. The upper surface of the bone carries the exoccipitals at the sides, and the middle part of its upper surface is somewhat depressed and supports the brain. On the ventral surface the bone is soon covered by the basisphenoid but contributes to the tubera.

The basisphenoid is a large and remarkable bone; on its lower surface two strong ridges continue the tubera forward and terminate in the basipterygoid processes, whose flat articular faces look well to the front. It is possible that the basipterygoid process is pierced by a foramen Vidianum, but this is not certain. Between these ridges is a very deep groove, which in front passes upwards into the skull, separating the basipterygoids. From the sides of the bone immediately below and in front of the fenestra ovalis, a short but relatively powerful process passes outwards and backwards and ends freely. On the upper surface the basisphenoid is

\* For explanation of the Plates see p. 747.

much excavated in the middle, and its lateral borders rise to the opisthotics. The upper surfaces of the processes spoken of above are deeply grooved, and the grooves from them pass on to the body of the bone, forming a depression stretching right across it. In front of this is a ridge which marks the posterior border of the pituitary fossa, whose surface is not very well preserved in any case.

Text-figure 1.

*Procolophon trigoniceps.*

- A. Base of skull and otic region viewed from below and the right side.  $\times 2$ .  
 B. View of left side of brain-cavity.  $\times 2$ .

*B.Oc.*, Basioccipital; *B.Pr.*, Basispterygoid processes; *B.Sp.*, Basisphenoid; *Ex.Oc.*, Exoccipital; *F.Jug.*, Foramen jugulare; *F.V.*, Foramen Vidii?; *Fen.Ov.*, Fenestra ovalis; *Op.O.*, Opisthotic; *Pr.O.*, Pro-otic; *Vesti.*, Vestibule.

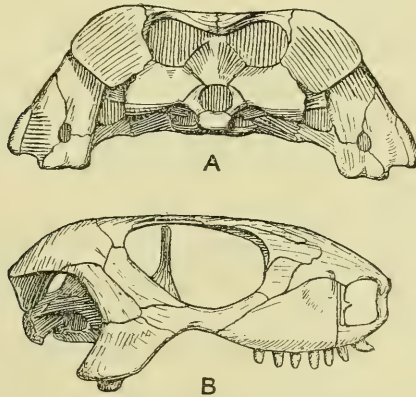
The exoccipital is a bone of medium size, articulating with the upper surface of the basioccipital. It is comparatively long, and is pierced at about the middle of its length by two small foramina for the twelfth nerve, which lie just above its lower border. These two openings soon join and open in a single foramen on the outside of the cranium. The bone extends outwards for a little distance with its upper part in contact with the posterior surface of the paroccipital, from which bone it is separated below by the large, round foramen jugulare. The exoccipital forms the

side-wall of the foramen magnum, and its upper end is in contact with the supraoccipital.

The opisthotic is a large and powerful bone. Its inner end was largely cartilaginous, and its ossified part does not touch the basis cranii. Part of its posterior face is covered by the exoccipital, lateral to which it forms the very deep and massive paroccipital process, the distal upper corner of which is connected with the tabulare. The front of the paroccipital process is covered by the pro-otic, and the two bones combine to form a rounded groove on the lower surface in which the stapes lies.

The pro-otic is applied to the anterior face of the opisthotic, and resembles that bone in having a largely cartilaginous inner end. This is, however, larger in area and is clearly pierced by a foramen, or possibly two, for the VIIth and VIIIth nerves. On the inner side of the skull the inner ear is widely open and lies high in the side-wall of the brain-cavity. The whole condition is extremely like that in a tortoise. The front edge of the pro-otic has a large incisura for the trigeminus, below which is a prominent process. The fenestra ovalis is a very large irregular hole in the bony skull.

Text-figure 2.



*Procolophon trigoniceps*.

A. Posterior aspect of skull.  $\times 1$ .

B. Right lateral aspect of skull.  $\times 1$ .

Composite figures from three perfect skulls.

The supraoccipital is a very delicate bone, whose inner aspect is not known; externally it is exactly like that of a lizard, touching the parietals by a very small point, if at all directly.

The stapes is a relatively thick rod, whose outer end is expanded into a plate.

There is a slender epipterygoid, which expands below and is broadly fastened on to the outer surface of the pterygoid just

outside its articulation with the basisphenoid. This rises in the skull till its upper end nearly touches the parietal lateral to the parietal foramen.

The general structure of the roof of the skull is already quite familiar from the figures and descriptions of Seeley, Smith Woodward, and Broom. The figures in this paper will, I hope, explain any doubtful points: the relations in important regions are described below.

The quadrate is a comparatively small bone; it has a small condyle for the mandible, above which it rises vertically. The body of the bone is in contact with the very large and massive quadratojugal at its lateral border; it is then separated from this bone by the quadrate foramen. Above this level the whole posterior surface of the quadrate is covered by the squamosal. The quadrate sends a long process inwards which is covered posteriorly by the posterior ramus of the pterygoid.

The squamosal is a bone of medium size which may be described as consisting of three parts. The posterior and largest of these covers much of the back of the quadrate; it curves round to form the second region, which lies entirely on the outer side of the skull, having sutures with the quadratojugal, jugal, post-orbital, and tabulare. The third part arises from the other two and passes inwards and backwards over the otic notch to nearly or quite touch the parietal. The whole of this part is covered by the tabulare.

The tabulare is a very large bone forming the posterior corner of the flat upper surface of the skull. Its anterior end overlaps the parietal and squamosal to a very large extent, but its hinder margin is free, and is deflected to meet the upper posterior corner of the paroccipital.

Of postparietals there is usually no trace, but in the skull of the female skeleton, which is well preserved, there are quite clearly a pair of small bones articulating with the pointed mesial posterior ends of the parietals. These are very small, only about 1 millimetre square, but can only be interpreted as vestigial post-parietals. They stand out quite freely and touch no underlying bones.

An interesting point is that the nasal cavity is very largely separated from the very large orbit by plates arising from the lachrymal and prefrontal.

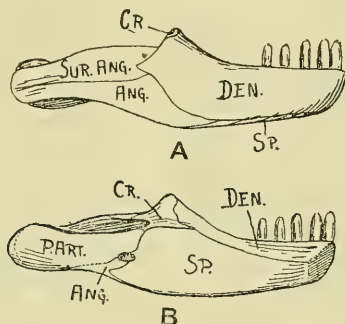
The septomaxilla is a small bone articulating with the premaxilla and nasal and forming the posterior border of the nostril.

The material at my disposal has shown no trace of a parasphenoid, but Dr. Broom has recorded it in an Albany Museum specimen.

A curious feature of the very well-preserved skull of the male skeleton is the presence of a small depression with rather steep walls on the outer surface of the maxilla and nasal, just behind the upper end of the septomaxilla. This probably lodged a superior labial gland.

One feature of the skull about which there has been some dispute is the presence or absence of a foramen in the temporal region. There is no doubt that Broom is quite correct in denying its presence, but in justice to Prof. Seeley and the British Museum mason, it should be pointed out that the hole in this region in their skulls is not an artifact, but is due to a rotation inwards of the posterior edge of the postorbital as a result of slight crushing.

Text-figure 3.

*Procolophon trigoniceps.*

(A) Outer, and (B) Inner aspects of lower jaw.  $\times 1$ .

*Ang.*, Angular; *Cr.*, Coronoid; *Den.*, Dentary; *P. Art.*, Prearticular;  
*Sp.*, Splenial; *Sur. Ang.*, Surangular.

Composite figures from two specimens.

The structure of the lower jaw will be understood from text-fig. 3. The sutures separating the prearticular from the articular and angular are not clear in any specimen, but I think they are faintly shown as figured in the skull of the female skeleton. Every other suture is obvious.

The coronoid extends forward between the dentary and splenial for some distance.

*Vertebral column.*—There are twenty-six presacral vertebrae. The axis has a powerful spine, very long anteroposteriorly; and powerful posterior zygapophyses, which are continued forwards into a broad table. There is a large intercentrum between the centrum of the axis and the odontoid. The odontoid is not known in detail.

The atlantal intercentrum is large and its anterior face forms part of the cup for the occipital condyle. There is a pair of neural arches to the atlas. These are separated posteriorly by the neural spine of the axis; each has a facet on its inner face by which it articulates with the odontoid, anteriorly it has an articular face for the basioccipital. In front its upper surface is overlapped by the proatlas, and behind it articulates with the

prezygapophysis of the axis. The atlas is very short from back to front. The proatlas is paired (and articulates with the skull?).

The remaining presacral vertebræ are all much alike, but their neural arches become heavier as they are traced backward. The centra are completely pierced by the notochord and are considerably constricted, the lower surfaces, however, being flattened. The articular ends are expanded. There are intercentra between all the presacrals; these are single crescentic bones of an ordinary character. Broom records paired intercentra between the third and fourth vertebræ. I have not seen this region.

The neural arches are heavy, extremely so in the posterior part of the column. The articulating faces of the zygapophyses are flat and placed horizontally throughout. The neural spines are only represented by very short projections on the top of the swollen neural arch.

The rib articulations are single, carried at the end of a short transverse process, contributed to by both arch and centrum, in the anterior part of the column; with the progressive increase in size of the neural arch this process becomes obsolete, but the rib articulation remains essentially similar.

The first sacral vertebra is very short anteroposteriorly; it carries a very large rib articulating with both arch and centrum, and its neural arch is heavy. The anterior zygapophyses are wide apart, but the posterior facets are placed close together. The second and third sacral vertebræ have slender arches, but their articulation-faces are still flat and horizontal. The caudal vertebræ are not well exposed in any specimen; anteriorly they resemble the posterior sacrals, but further back they develop fairly high spines and long chevron bones. It is not known how far back they carry ribs.

The ribs are single-headed throughout and present no feature of interest. There is some evidence of a rib on the atlas, and there are certainly ribs on all the other presacral vertebræ except, perhaps, the last two or three, on which I have not seen any; even in a well-preserved skeleton, if present, they were short.

*Abdominal ribs.*—Three specimens show the whole series of abdominal ribs. The plastron is extremely reduced, consisting of at most five series of transverse rows each composed of six very small slender elements. These are divided into two groups, which do not meet in the middle line. The whole arrangement is about a centimetre from back to front, and lies about 15 mm. behind the pectoral girdle, *cf.* text-fig. 4, B.

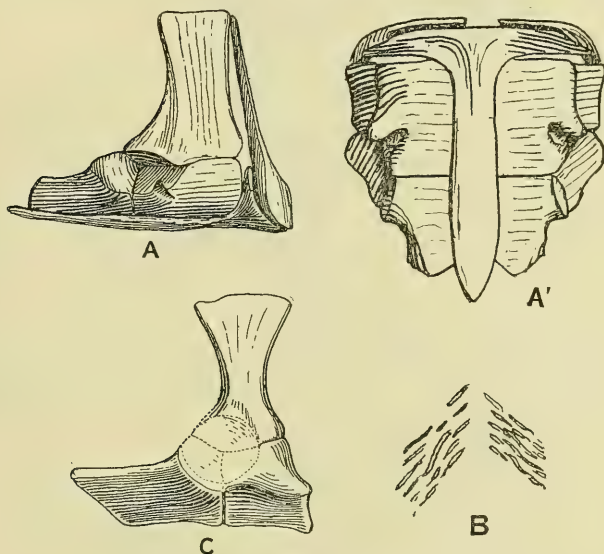
*Pectoral girdle.*—The general features of the pectoral girdle have long been known.

The scapula stands nearly vertically and is a simple bone without an acromion. It has a ridge down its outer surface and thickens considerably at the glenoid cavity. The anterior part of the lower margin of the bone is in contact with the precoracoid, and for the anterior half of this union the external surface of one bone is directly continued on to the other. Posteriorly this

surface is interrupted by the notch which forms the glenoid cavity. The posterior part of this is formed by the coracoid, which articulates with the scapula and precoracoid, and extends backwards behind them for a long distance.

The glenoid cavity thus formed by all three bones looks almost directly outwards and is essentially a trihedral pit; it must have been covered during life by a thick pad of cartilage, but can never have shown any trace of the screw-shape shown in early *Cotylosaurs* such as *Diadectes*, *Labidosaurus*, and, to a less extent, "*Pariasaurus*."

Text-figure 4.



*Procolophon trigoniceps*, ♂.

- A. Right lateral aspect of shoulder-girdle.  $\times 1$ .
- A'. Ventral aspect of shoulder-girdle.  $\times 1$ .
- B. Ventral aspect of shoulder-girdle, and abdominal ribs.  $\times 1$ .
- C. Right side of pelvis from outside.  $\times 1$ .

The so-called notch in the precoracoid proves when fully exposed to be really a foramen passing through the bone and opening on its upper surface. Its most remarkable feature is the strong rounded ridge which forms its anterior border on the lower surface.

The clavicles are large bones, beginning at the upper margin of the scapula; they run down the whole anterior border of that bone and then turn suddenly in, being vertically expanded and applied to the anterior face of the T-shaped interclavicle.

The humerus of *Procolophon* is a very remarkable bone. The

head is a large triangular area, obviously covered by a thick pad of cartilage during life.

The anterior lower corner of the head gives rise to a ridge which rapidly subsides into the shaft and forms the only representative of the deltoid crest.

The anterior upper corner also gives rise to a ridge which passes down the dorsal and anterior edge of the humerus until it in turn passes into the shaft.

The posterior lower corner of the triangular head gives rise to a pronounced ulnar crest of much greater size than the radial expansion. The bone has a narrow shaft which expands into the wide lower end of the bone. This bears a prominent condyle for the head of the radius and one for the ulna. There is a large entepicondyle with a foramen.

The radius and ulna present no marked features.

The carpus and manus are exactly as Dr. Broom has already figured them; the radiale is unossified; in the male skeleton traces of its cartilage were preserved.

*Pelvic limb.*—The pelvis, as shown in my specimens, is rather different from that of Dr. Broom's specimen.

The ilium is high and narrow, it is supported by the three sacral ribs, and placed almost vertically; it forms about a third of the acetabulum, above which it is thickened to form the usual process.

The pubis is an extremely massive bone, nearly square when seen from below, and pierced by the foramen; it articulates with its fellow so that the lower surfaces meet in an angle considerably less than two right angles; in other words, the lower surface of the pelvis is not flat. The upper surface of the pubis slopes down very rapidly in front.

The ischia present no special features.

The hind leg has already been well described and figured by Seeley and Broom; my specimens agree exactly with theirs.

The restoration of the skeleton in a walking attitude, text-fig. 5, is drawn entirely from the male skeleton.

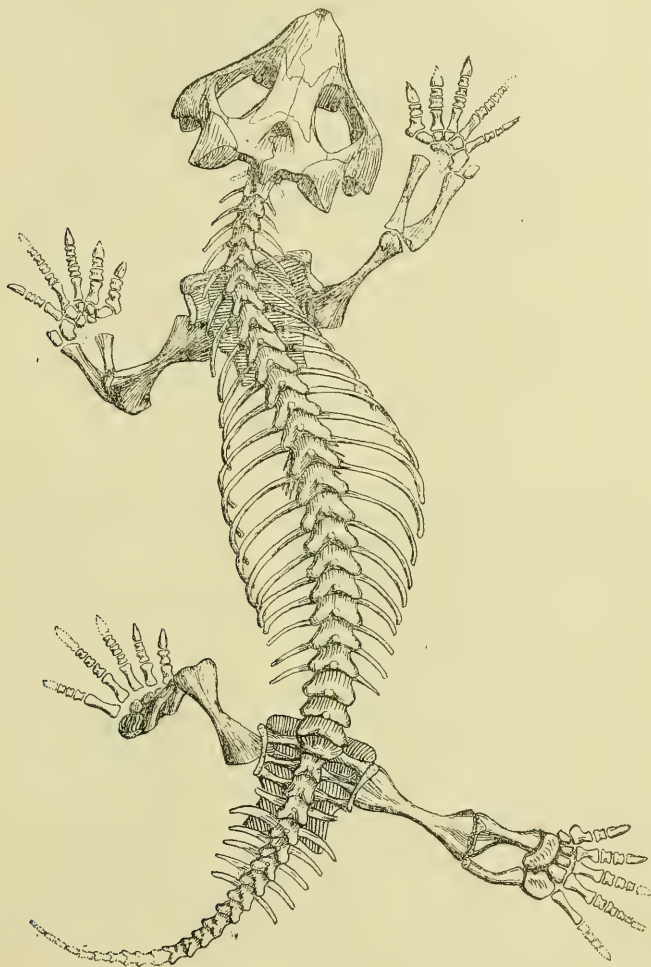
The length of the neck depends on the actual position of the pectoral girdle in the specimen, which is quite undisturbed, lying on the ventral surface with the fore legs placed straight back along the body and the soles of the two feet together along the tail. The head is turned sharply to the right, but as every bone is in close and accurate articulation this position must be a possible one. In the female skeleton the head is in a similar position, and the shoulder-girdle equally far back. The tail in the restoration is completed from the entire series of caudals of the female skeleton.

Taken as a whole *Procolophon* is very lizard-like in build, although it is rather massively constructed.

The male and female skeletons are of exactly the same length, as are their skulls. The dentition is quite similar in the two specimens, and I think there is not the slightest doubt that they

belong to the same species. The female skeleton is, however, much more lightly built, having narrower and more slender limb-girdles, and limbs which are less than three-quarters as long as those of the male skeleton and much less robust. Mr. Boulenger tells me that differences of this kind often distinguish the

Text-figure 5.



*Procolophon trigoniceps.*

Restoration of the skeleton of a male, all the bones except those in dotted outline being drawn from a single individual.  $\times \frac{1}{2}$ .

sexes in living Lizards, and I think it is extremely probable that the same reason accounts for the difference between my two skeletons.

### *Affinities of Procolophon.*

That *Procolophon* is a Cotylosaurian has been recognised by all recent workers. Its right to inclusion in this group depends on its roofed skull (it is perfectly obvious from the examination of well-preserved skulls that the large opening on either side is entirely an enlarged orbit and not, as has sometimes been suggested, a joint orbit and temporal fossa), and on the typically Cotylosaurian vertebrae which are very similar to those of *Labidosaurus*.

Mere reference of an animal to the Cotylosauria means very little, as that great group includes animals which differ at least as much from one another as do a Lizard and *Sphenodon*, or even a Tortoise and a Crocodile.

When discussing *Pariasaurus* recently I divided all Cotylosauria, after the removal of the very primitive *Seymouria*, into two groups, from the way in which they obtained a vertically standing quadrate, one process leading to the obliteration of the otic notch, the other to its exaggeration.

To the first group belong the Captorhinids, Pariotichids, and Pantylids; to the second, Diadectids and Pariasaurids.

*Procolophon* has an enormous otic notch, and of course falls into the second group.

*Procolophon* and its allies are the latest of all Cotylosauria, occurring, so far as is definitely known, only in the Trias after the disappearance of all other types. In consideration of their age we should expect to find many advances in their structure. [Any study of palæontology shows that all allied animals tend, with mere passage of time, to change their structure in certain definite ways which are common to whole groups and occur independently in different lines of descent. These changes, which are usually independent of the adaptations of the animals in which they occur, take place at different rates in the distinct lines, and the sets of changes of different parts of the same animal are independent and may proceed at very different rates. Changes of this type I refer to as advances; they are quite different from specialisations, which themselves are of two kinds, adaptations to some special mode of life, and what are usually regarded as specific characters, *i.e.* such differences between animals as form the typical Mendelian allelomorphs; it is very probable that these characters once established, perhaps as saltations, are very stable, and may persist in a recognisable form during a long series of advances.]

The advances in the structure of *Procolophon* are:—

1. The rounded occipital condyle.
2. The vertical quadrate.

3. The loss of the primitive connection between the squamosal and pterygoid.
4. The loss of the "supra-" and inter-temporal bones.
5. The reduction of the lachrymal so that it no longer reaches the nostril.
6. The release of the distal end of the stapes from the quadrate.
7. The short atlas and long axis.
8. The long neck.
9. The extreme reduction of the plastron.
10. The loss of the cleithrum.
11. The loss of the supraglenoid and glenoid foramina.
12. The loss of the screw-shaped glenoid cavity.
13. The loss of the fifth distal carpal.
14. The loss of the centralia tarsi and the fifth distal tarsal.

The specialisations in the structure of *Procolophon* are :—

1. The enlarged tabulare.
2. The enlarged quadratojugal.
3. The enlarged orbit.
4. The dentition.
5. The characteristic humerus.
6. The non-ossification of the radiale.
7. The three sacral vertebræ.

No other Cotylosaurians approach *Procolophon* in the number of its advances, no other form has the lachrymal excluded from the nostril, and none other has completely lost the screw-shaped glenoid cavity. These differences, however, are not of such a character as to preclude the possibility of *Procolophon* having been derived from some known earlier form; they are merely a result of its lateness in time.

The very large otic notch seems by itself to render any connection with the Captorhinidæ impossible; but of even greater importance is the difference in the brain-cases. *Procolophon* has the vestibule of the inner ear occupying the whole side-wall of the cranium, and in wide connection with the brain-cavity, exactly as in a Tortoise or *Sphenodon*. The Captorhinids, although the material is not sufficiently good for certainty, seem to have the vestibule placed very low down, as in a Therapsid; a difference of this character seems to me to render any idea of a close connection between the groups quite unbelievable.

So little is known of *Pariotichus* and *Pantylus* that their affinities are quite uncertain.

*Pariasaurus* differs from *Procolophon* in its very long, low brain-cavity, with a bony separation of the inner ear from the cranial cavity. It is, of course, a very much less advanced type, retaining a concave occipital condyle, a trace of the connection of the squamosal and pterygoid, a lachrymal reaching the nostril,

a cleithrum, a screw-shaped glenoid cavity, and a fifth carpal. A blood relationship between *Procolophon* and *Pariasaurus* is more probable than one between *Procolophon* and *Labidosaurus*, despite the very different specialisation of the two types.

*Diadectes* resembles *Procolophon* in its large otic notch, and apparently, to some extent, in the features of the cranial cavity. It differs, however, in the complete closure of the post-temporal fossæ by a union of the widened supraoccipital with the tabulares and postparietals. In addition to these phylogenetically important differences are many due to the very much less advanced nature of the type.

*Limnoscelis* differs in the apparent obliteration of the otic notch and in its closed post-temporal fossæ, in addition to the retention of many primitive structures.

The work of Boulenger and v. Huene has shown the very great resemblance between *Telerpeton* and *Procolophon*, and I have been able to confirm their accounts on a magnificent new skeleton of the latter lent to me by Mr. Taylor of Llanbryde.

Dr. Broom, when he first examined *Procolophon*, expressed his opinion that whilst technically a Cotylosaur it was really a primitive "Diaptosaurian," picking *Paleohatteria* as perhaps its nearest known relative. This choice was rather an unfortunate one, for it now seems almost certain that *Paleohatteria* is really a Therapsid.

This suggestion was, in fact, really founded on such features as the digital formula and the presence of abdominal ribs, which have proved to be common to all early reptiles. At the same time, the structure of the neural part of the skull does recall very strongly that of *Sphenodon*, or, so far as the interior of the cranial cavity is concerned, a Tortoise.

As I believe very strongly in the value of this part of the skeleton as an indicator of affinities, I think it probable that *Procolophon* has some real relationship to the unknown group of Cotylosaurs from which these two very diverse forms of reptiles sprung. I have carefully examined the skeleton of *Procolophon* in this connection, but can find no other resemblances between it and the more modern reptiles which are not also common to many other early forms. In particular the glenoid cavity seems incapable of having given rise to that of reptiles with a single coracoidal element, being curiously advanced in a different direction.

For the opportunity of collecting the material on which this paper is based, I am indebted to the assistance of the Percy Sladen Trustees, and to G. W. Crozier, Esq., of Donnybrook, W. Southey, Esq., of Tentergate, and P. Goosen, Esq., of Haslop Hill, S. Africa, without whose hospitality and interest I could have done nothing.

The beautiful preparation of the male skeleton was made by Mr. R. Hall, of the British Museum.

EXPLANATION OF THE PLATES.

PLATE I.

*Procolophon trigoniceps*.

Dorsal aspect of the nearly complete skeleton of a male (B.M. R. 4087).

Collected by the author at Haslop Hill, Dist. Tarka, S. Africa.

PLATE II.

*Procolophon trigoniceps*.

Ventral aspect of the specimen shown in Pl. I.

PLATE III.

*Procolophon trigoniceps*.

The specimen shown in Pl. I., from the left side.







1.



2.

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MORMOSAURUS SEELEYI.





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TITANOSUCHUS FEROX

42. The Deinocephalia, an Order of Mammal-like Reptiles.  
By D. M. S. WATSON, M.Sc., F.Z.S., Lecturer on  
Vertebrate Palæontology in University College,  
London.

[Received May 7, 1914: Read May 19, 1914.]

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In 1851 Andrew Geddes Bain forwarded to the Geological Society of London a series of fossil bones from the River Gamka, Great Karroo, South Africa, which he recognised as different from all the others he had collected.

These bones—a femur, humerus, ilium, vertebræ, and portions of skull-bones—were the first fragments of a Deinocephalian to be found in South Africa. Many years before, however, the copper mines of the Ural Mountains had yielded fragmentary bones which were described by Kutorga; these are now known to belong to Deinocephalians. The first South African type to be described was *Tapinocephalus atherstonei* Owen, the snout of which was excellently figured and shortly described in the 'Catalogue of Fossil Reptiles of South Africa in the British Museum.' In this work Owen described some vertebræ and limb-bones belonging to Deinocephalia, but by a confusion in localities attributed many of them to *Pariasaurus*. Some years later Owen described the very fragmentary remains of *Titanosuchus*.

\* For explanation of the Plates see p. 786.

The first account of a skull which was in any way complete was written by H. G. Seeley on material of *Rhopalodon* and *Deuterosaurus* from the Urals. Subsequently the same author described a good skull belonging to the South African Museum as *Delphinognathus conocephalus*.

Except for purely systematic descriptions by Broom of four new genera and five new species founded on most unsatisfactory material, nothing further was published till, in 1909, this author gave a short and, as it has proved, somewhat inaccurate account of two skulls in the British Museum collected by Prof. Seeley. Subsequently Broom published a much better account of the type skull of *Delphinognathus* and brief descriptions of several new genera, one of which gave a complete knowledge of the lower jaw.

Finally, Haughton has published a short account of a large skull referred, perhaps correctly, to *Tapinocephalus atherstonei*.

The British Museum (Natural History) contains a large amount of Deinocephalian material in the form of more or less fragmentary skulls and small associated sets of bones. From this it is possible to get some idea of the form and structure of a member of the group, and to give a nearly complete account of the morphology of the skull.

The description of the Tapinocephaloid skull now given is founded on the following material:—

I. R. 1705. The type skull of *Tapinocephalus atherstonei*, represented by the right side of the occipital region up to the orbit, the left supraorbital region, and the anterior part of the face.

II. R. 3594. The skull already described by Broom as *Tapinocephalus atherstonei* which really belongs to a new genus (Pl. IV. and text-figs. 1-4).

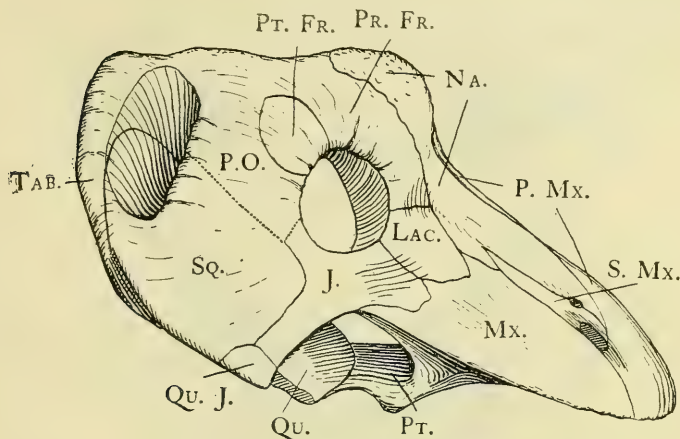
This skull has lost the basioccipital condyle and the left quadrate region. It is very slightly distorted by pressure but otherwise is very well preserved, having been completely freed from a most intractable matrix by Mr. R. Hall, of the British Museum. When Dr. Broom described it, the whole outer surface was covered with a thin layer of matrix which has proved to be readily removable, so that all the sutures of the face are clearly and definitely shown; most of those figured by Broom are wrong.

III. R. 3596 is a specimen in the Seeley collection from De Cypher, Gough, consisting of a skull (text-figs. 5-7) from which the face in advance of the prefrontal had fallen away before fossilisation, the two dentaries, with some limb-bones and vertebrae. Although also referred by Broom to *Tapinocephalus*, this skull is generically distinct not only from this type but also from R. 3594.

IV. 49385 is a specimen, Q of T. Bain's collection, from Warm Bad, Gough, which consists of the posterior part of the skull,

lacking most of the quadrates, and the anterior part of the face, which is only connected with it by documentary evidence (text-figs. 8, 9). This specimen also represents a new genus.

Text-figure 1.

*Mormosaurus seeleyi*, gen. et sp. n.

R. 3594 B.M.N.H. Type-skull. Right lateral aspect\*,  $\times \frac{1}{6}$

J., Jugal; LAC., Lachrymal; Mx., Maxilla; NA., Nasal; P.O., Postorbital; PT. Pterygoid; PT.FR., Postfrontal; PR.FR., Prefrontal; P.Mx., Premaxilla; QU., Quadrate; QU.J., Quadratojugal; S.Mx., Septomaxilla; SQ., Squamosal; TAB., Tabulare.

Although these skulls belong to four different genera, they agree so closely in their fundamental architecture that I have used them all in the following description, which is, however, founded as far as possible on R. 3594, from which the account of the face and palate are almost wholly drawn.

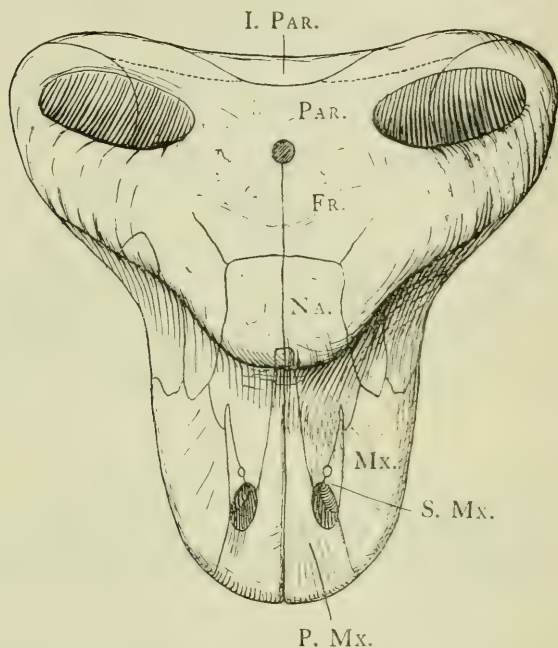
[This method I hold to be perfectly legitimate; it is as if we were describing the characteristic structure of a mammal's skull from incomplete but complementary skulls of a bear, a dog, and a cat.]

The Tapinocephaloid skull (text-figs. 1-9) has an extraordinarily large and massive cranial portion beside which the often sharply marked off face seems rather feeble. The whole of the bones on the dorsal surface of the postorbital region fuse together and thicken probably throughout the animal's life, until as much as

\* Skulls from the Karroo of South Africa are usually distorted; in many cases this is of the nature of a simple sheer, which is very easily corrected in making drawings. In the figures of this paper this correction has been made, and each side is restored by comparison with the other. Nothing is introduced into them without clear evidence on at least one side. All the figures are projections and not perspective drawings.

fifteen centimetres of solid finely cancellar bone may be formed over the brain. The bones of the face, although they may be two centimetres thick, never fuse, and were readily disarticulated in the adult skull.

Text-figure 2.



*Mormosaurus seeleyi*. Dorsal aspect of the type-skull,  $\times \frac{1}{2}$ .

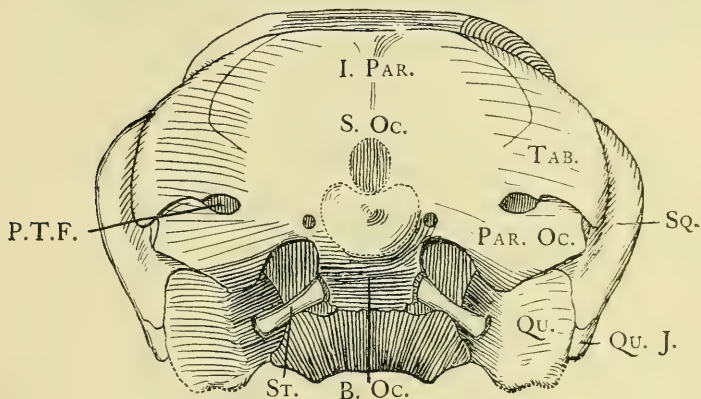
Reference-letters as before, with:—FR., Frontal; I.PAR., Interparietal;  
PAR., Parietal.

The whole occipital and otic region of the skull (text-figs. 3, 7) has fused into a mass of bone in which no sutures are visible in the material at my disposal. On the whole this region is very like the corresponding part of *Lystrosaurus* which I have already described. It forms a thick, vertically placed plate of bone pierced through the middle by the relatively small brain-cavity. This is throughout higher than wide, and has not been cleaned in any specimens; fractures, however, show that it possessed the characteristic Therapsid character of having the large opening to the vestibule placed very low down in the skull. The floor of the brain-cavity rises considerably towards the front.

The basioccipital condyle (text-figs. 3, 4, 7) is single, large, and slightly pedunculate (R. 3596); it has a slight median depression representing the notochordal pit. Below the condyle, the basi-

occipital forms a vertical area, which may be very high and wide (text-fig. 7) (R. 3596) or comparatively small. The sides of this area must be formed by the paroccipitals for some distance, as the fenestræ ovals lie at the sides well below the condyle. The corresponding flat area in front is formed by the basisphenoid. There are no distinct tubera basisphenoidalia, or basiptyergoid processes, but the posterior ends of the pterygoids articulate and indeed fuse with the lower margin of the vertical area. From

Text-figure 3.



*Mormosaurus seeleyi*. Posterior view of the type-skull,  $\times \frac{1}{6}$ .

Reference-letters as before, with:—B.Oc., Basioccipital; PAR.OC., Paroccipital; P.T.F., Post-temporal fossa; ST., Stapes.

between them the narrow parasphenoid rises as a vertical plate, separated from much of the front of the basisphenoid by the deep, short notch which is the pituitary fossa. This fossa is bounded laterally by very low ridges which run upwards on the vertical anterior face of the basisphenoid until they terminate in low processes which are the processi anteriores prootici. The prootic of course contributes to the fenestra ovalis, above which it is perforated by the aquæductus fallopii for the VIIth nerve.

The otic and supraoccipital regions of the skull are in contact with the following bones:—

The upper outer corner of the posterior face of the large paroccipital process with the tabulare.

The outer end and front face of the paroccipital process with the squamosal.

The lower part of the front face of the paroccipital process with the quadrate.

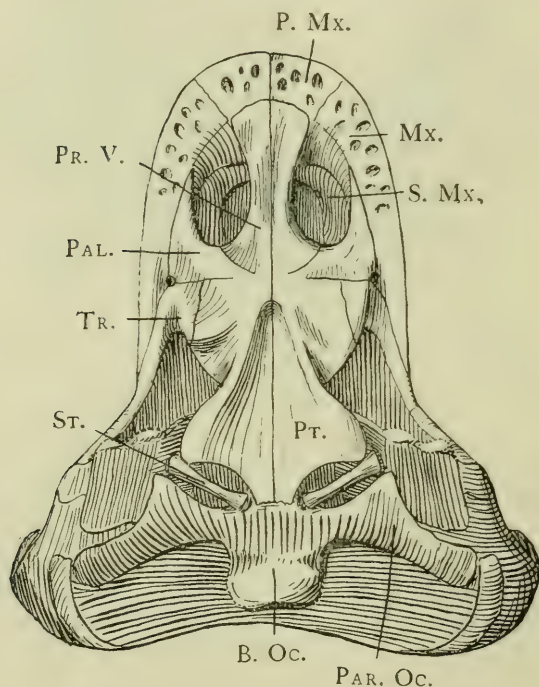
The posterior surface of the supraoccipital region is covered by the interparietal and tabulares. Its upper margin (and part of the front face?) by the parietal (and postorbital?).

The parasphenoid (text-fig. 9, PAR.SP.), as has been described above, rises from the front face of the basisphenoid. It is very short antero-posteriorly and rises nearly vertically in the skull about to the level of the anterior inferior process of the prootic; its upper end is then split and receives the lower end of the ethmoid.

The ethmoid is a remarkable bone extremely like that of *Endothiodon*.

Its lower border is clasped by the split upper edge of the parasphenoid, from which it rises as a narrow vertical plate; in front this is continued to the roof of the skull, but behind it

Text-figure 4.



*Mormosaurus seeleyi*. Palatal aspect of the type-skull,  $\times \frac{1}{5}$ .

Reference-letters as before, with:—PR.V., Prevomer; PAL., Palatine;  
TR., Transverse bone.

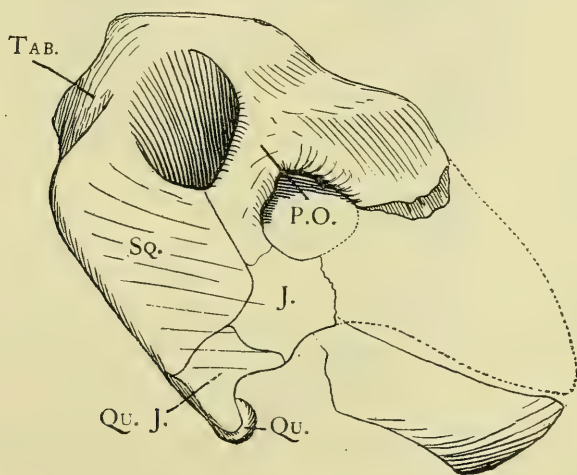
splits into two branches which rise to the frontals and leave between them a small cavity for the olfactory lobes of the brain. The nasal nerves leave by a pair of openings between the median septal part of the ethmoid and the rest of that bone. The

ethmoid is received in a groove on the lower surface of the frontals (and parietals?) and extends so far backwards that it nearly, if not quite, touches the supraoccipital.

The interparietal (I. PAR.) is a flat bone entirely on the back of the skull, where it overlaps the supraoccipital below and the tabulares at the sides. The rest of its front face is in contact with the hinder ends of the greatly thickened parietals.

The tabulare (TAB.) is a large bone forming a good deal of the occipital surface. It is wedged in between the postorbital and interparietal (R. 3594), and passes outwards above the post-temporal fossa to touch the outer end of the paroccipital. The outer part of its front face is in contact with the squamosal, and its thick outer border joins with this bone to make a distinct auditory meatus.

Text-figure 5.



*Prigalion oweni*, gen. et sp. n.

Right lateral aspect of the type-skull. R. 3596 B.M.N.H.  $\times \frac{1}{6}$ .

Reference-letters as before.

The squamosal (Sq.) is a large bone which has a powerful articulation with the end of the paroccipital process; above the articulation a strong ramus runs inwards along the front face of the tabulare to overlap the postorbital. Immediately to the outside of its articulation with the paroccipital process the bone overlaps the upper end and some of the posterior surface of the quadrate. Finally, the bone is completed by a powerful ramus which forms part of the outer wall of the skull, articulating with the lateral border of the quadrate and ending in suture with the quadratojugal, jugal, and postorbital.

None of the specimens shows clearly all the sutures bounding

the parietal, but it is certain that the two bones met in a median suture which is only interrupted by the long cylindrical tunnel which forms the large pineal foramen.

The posterior border of the bone is covered by the interparietal. Anteriorly it must meet the frontal, but the suture is never visible. The lateral border is completely covered by the post-orbital.

The excessive thickness of the bones makes them come into contact with the upper border and anterior face of the supra-occipital.

The postorbital (P.O.) is a large and very remarkable bone. It forms the massive bar behind the orbit, and has a very long suture with the squamosal in the zygomatic arch below the temporal fossa.

Above the orbit in R. 3594 it meets the small post-frontal, but in that specimen on its lower surface (on the right side) it can be distinctly seen to join the prefrontal in a long suture running inwards nearly to the middle line. The extremely thick and massive bone then meets the parietal and covers the whole of its outer surface, sending out a process in contact with the front face of the interparietal and tabulare to be finally covered by the tip of the parietal ramus of the squamosal, so that the temporal fossa is entirely bounded by these two bones.

The sutures between the postorbital, frontal, and prefrontal are not visible on the outside of the skull.

The postfrontal (Pt.Fr.) is a very small bone forming a small part of the orbital margin and entirely surrounded by the prefrontal and postorbital (R. 3594).

The prefrontal (Pr.Fr.) is a very massive bone forming the front upper quadrant of the orbital margin. On its ventral surface it has a long suture with the postorbital and likewise joins the postfrontal, frontal, nasal, and lachrymal.

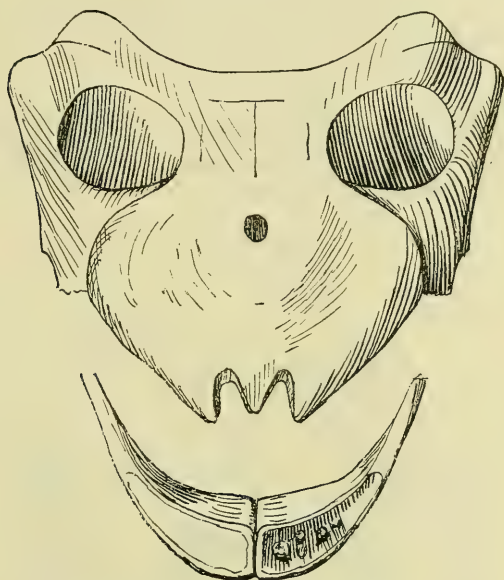
The lachrymal (Lac.) (R. 3594) is a small bone forming the front of the orbit and articulating with the prefrontal, nasal, maxilla, and jugal. There is no lachrymal foramen.

The nasal (Na.) (R. 3594) is a large bone which plays a great part in the structure of the face. The two bones are in contact in the middle line posteriorly, where they are very thick, but their thinner anterior portions are separated by the very long internarial processes of the premaxillæ. The outer border of the nasal has a suture with the prefrontal, lachrymal, maxilla, and septomaxilla, and is entirely excluded from the nostril by the latter bone. The visceral surface of each nasal has a sharp ridge, the two together forming a groove for the olfactory nerves.

The premaxilla (P.Mx.) of R. 3594 is a very remarkable bone. It has a suture with its fellow, with which it forms the rounded extremity of the snout. Its tooth-bearing margin is short and wide, and its inner edge forms part of the anterior border of the posterior naris. Medial to this opening it sends back a process along the upper surface of the prevomer. The dorsal surface of

this process forms a floor to the anterior part of the nasal cavity, and its outer border is in contact with the septomaxilla. The outer side of the premaxilla has a powerful articulation with the maxilla. In R. 3594 the facial part of the bone is continued upwards by a long and slender internarial process which separates the nasals for a great distance.

Text-figure 6.



*Psigalion oweni*. Type-skull, dorsal aspect,  $\times \frac{1}{6}$ .

The maxilla (Mx.) is a bone with few remarkable features; in front it joins the premaxilla, and thence backwards forms a large area of the face. It is completely excluded from the border of the external naris by the septomaxilla, with which in R. 3594 it has a long suture. In this specimen it then has a short contact with the nasal and is finally terminated by sutures with the lachrymal and jugal. On the palate the maxilla is only represented by its wide tooth-bearing edge and forms part of the border of the choana; for the rest of its length it is in contact with the palatine and transverse bones.

The septomaxilla (S.Mx.) is a variable bone in Tapinocephaloids. In R. 3594 it has an internarial part which unites by suture with the premaxilla to form a floor to the nasal cavity; it then sends back a large facial part which forms the whole of the posterior border of the nostril and separates the nasal and

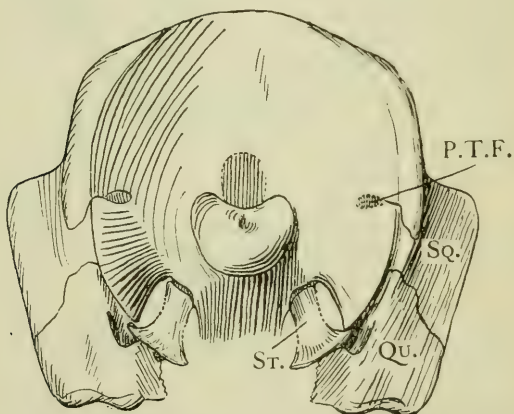
maxilla for a long distance; it is in contact with the maxilla throughout its length, but is separated from the nasal just behind the nostril by a foramen about a centimetre long and .5 cm. wide.

In 49385 the septomaxilla is entirely within the nostril, in which it forms an irregular curved plate, having a suture with the premaxilla and forming a rudimentary floor to the nasal cavity. Its outer border is in contact with the maxilla except for a small foramen of irregular shape (text-figs. 1, 2).

The jugal (J.) is a comparatively small bone which forms about a quarter of the orbital margin: in front it terminates in sutures with the lachrymal and maxilla, and on its inner surface with the transverse bone. Behind the orbit it has a suture with the quadratojugal, squamosal, and postorbital.

The quadratojugal (Qu.J.) is a small bone on the side of the skull; its end covers the outer border of the quadrate, from which it is not separated by a foramen quadrati. Above it touches the squamosal and in front the jugal.

Text-figure 7.



*Paigalion oweni*. Type-skull, posterior aspect,  $\times \frac{1}{2}$ .

Reference-letters as before.

The quadrate (Qu.) is a large bone whose lower border forms the double condyle for the lower jaw; above this it rises in the skull with its outer edge connected with the quadratojugal and squamosal. The upper end of the bone and some of its hinder surface is overlapped by the squamosal.

Passing inwards from the body of the bone is a powerful pterygoid ramus, which overlaps from the squamosal on to the front face of the paroccipital process. Much of the rest of the posterior face of this ramus is overlapped by the pterygoid. Some distance above the condyle, where the pterygoid ramus joins

the body of the quadrate, there is a step which may (R. 3596) be for the outer end of the extremely massive stapes.

The posterior end of the pterygoid is lightly applied to and probably usually fused with the lower end of the basisphenoid at the side of the parasphenoid. From the side of the bone in this region (49385) a small process is given off which curves round so as to shield the front of the fenestra ovalis. From this process a slender rod rises very high in the skull with its posterior edge nearly in contact with the front of the prootic: although not separated by visible suture it is probable that this bone is the epipterygoid. In R. 3594 there is a small fragment in contact with the parietal in the region of the hinder end of the ethmoid which may be the upper end of this bone.

From its articulation with the basisphenoid the pterygoid passes forwards and outwards; the outer wing is the quadrate ramus, which on account of the remarkable form of the skull and the forward throw of the quadrate, forms a nearly flat, horizontally placed sheet of bone overlapping the posterior surface of the quadrate. In front of this the pterygoid narrows and then rather suddenly widens and passes outwards to the transverse bone. Much of the anterior border is in contact with the palatine in a straight suture, but there is in 49385 a small medial process which extends forwards to touch the prevomer.

The dorsal surface of the anterior part of the pterygoid is produced into a high flange rising in contact with its fellow (with which it may be fused, 49385) as a median septum in the facial part of the skull.

The transverse bone (Tr.) is separated from the pterygoid by incomplete but quite definite and certain sutures on both sides of R. 3594. It unites with the pterygoid to form a low flange against the side of the lower jaw, and runs outwards, having a long suture with the palatine in front to the maxilla and jugal. Where the maxilla, palatine, and transverse meet there is apparently a very small suborbital fossa only about .5 cm. in diameter.

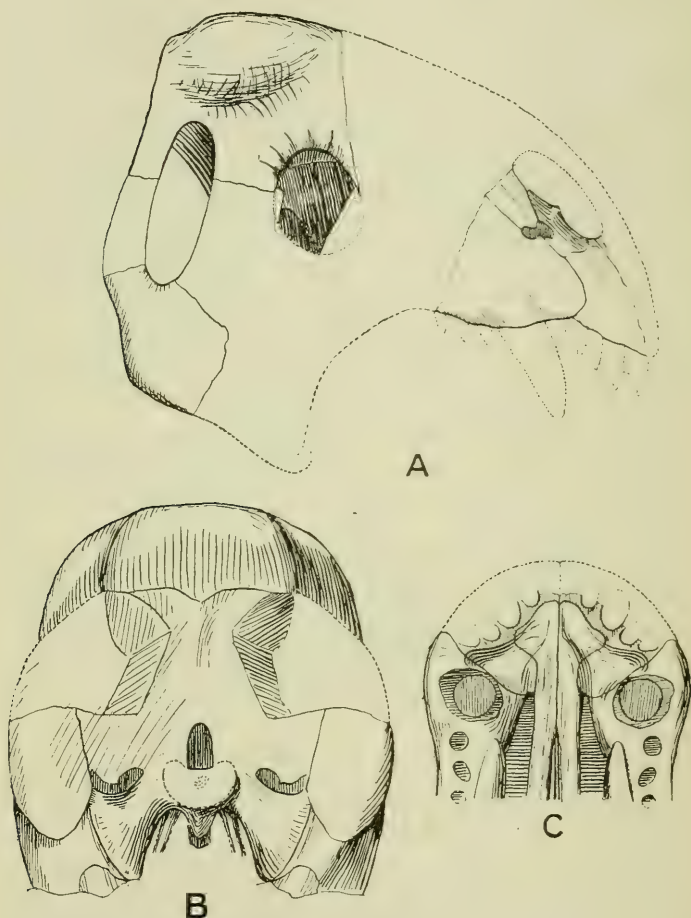
The palatine (PAL.) is a bone of medium size which has a suture with the transverse and pterygoid posteriorly, with the pterygoid and prevomer medially; its anterior border forms a good deal of the posterior naris and its outer edge has a long suture with the maxilla.

The prevomer (PR.V.) is a rather remarkable bone. Behind it has a suture with the palatine, for some distance its medial surface is separated from that of its fellow by the thin vertical plate made by the pterygoids. Further forward the two bones meet in the middle line, and from this point forwards their upper surface is to a variable extent overlapped by special processes of the premaxillæ. The outer edge of the prevomer forms the whole of the inner margin of the posterior naris. From the upper margin of the bone a thin flange rises which leans inwards till its upper edge touches that of the septum formed by the pterygoids. This flange

gradually declines in height, but in R. 3594 separates the sub-narial process of the premaxillæ for some distance.

In 49385 the prevomer underlies the premaxillæ to the posterior edge of the alveoli.

Text-figure 8.



*Lamiasaurus newtoni*, gen. et sp. n.

A. Right lateral aspect of the type-skull,  $\times \frac{1}{2}$ . B.M.N.H. 49385.

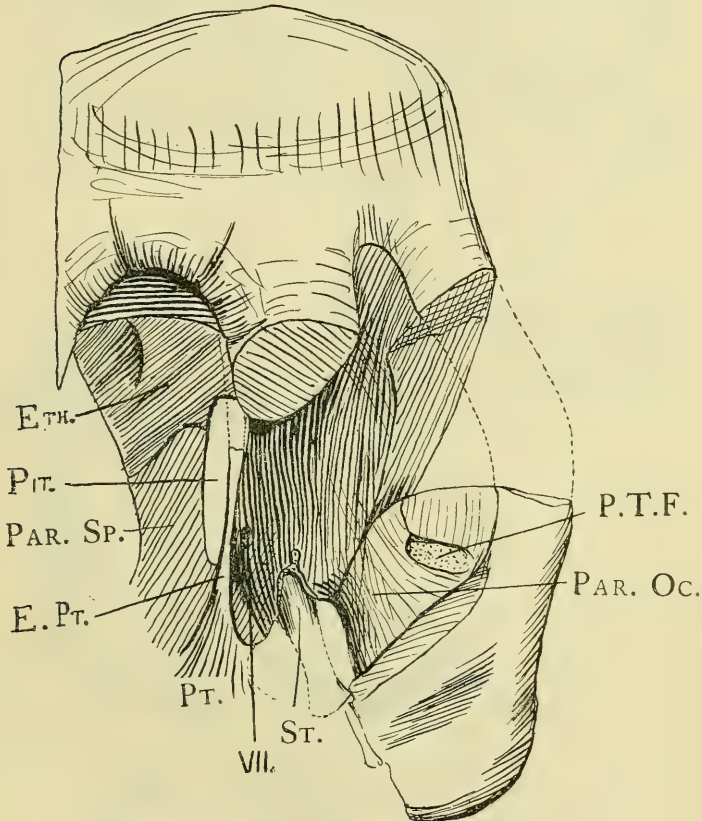
; There is no evidence of the relative position of the back of the skull and the snout.

B. Posterior aspect of the type-skull,  $\times \frac{1}{2}$ .

C. Anterior part of the palate of the type-skull,  $\times \frac{1}{2}$ .

The stapes (St.) in all *Deinocephalia* is a massive rod with few features; in 49385 it apparently fuses with the posterior lip of the fenestra ovalis. In R. 3596 it is of extraordinary size; the distal end, which is directly and powerfully articulated with the quadrate, being nearly 5 centimetres wide and 2 thick. It is not perforated for a stapedial artery.

Text-figure 9.



Type-skull of *Lamiasaurus newtoni*, external aspect of the bones of the brain-case.

Reference-letters as before, with:—ETH., Ethmoid; E.PT., Epipterygoid; PAR.SP., Parasphenoid; PIT., Pituitary fossa; VII., 1-foramen fallopii.

The Tapinocephaloid lower jaw is represented in the British Museum only by the two dentaries of R. 3596 (text-fig. 16, A); as Dr. Broom has recently published an account of the jaw this lack is of little importance.

The post-cranial skeleton of *Tapinocephaloids* is represented by the following material:—

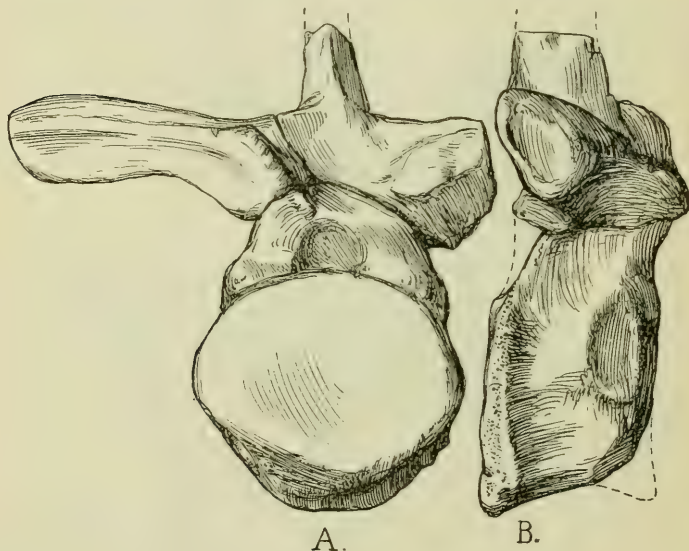
The type of *Tapinocephalus atherstonei*:—The matrix of this specimen is a dark blue grey limestone full of small lamellibranchs; these are the only bones in the collection in such a matrix.

The fragmentary skull, two nearly complete and several other dorsal vertebræ, and some caudals.

The type of *Phocosaurus* Seeley:—A sacrum and ten imperfect dorsal vertebræ. The two ilia and pubes, one ischium, two imperfect femora, a tibia, two fragmentary scapulæ, and pre-coracoids, one coracoid, two humeri, and one ulna.

The only fragment of skull associated with this is a bit of palate showing part of the two pterygoids and a part of the palatine. This agrees exactly with R. 3594, but is about half as large again.

Text-figure 10.



A dorsal vertebra of the type-specimen of *Tapinocephalus atherstonei* Owen,  $\times \frac{1}{3}$ .

A. Anterior aspect.

B. Lateral aspect.

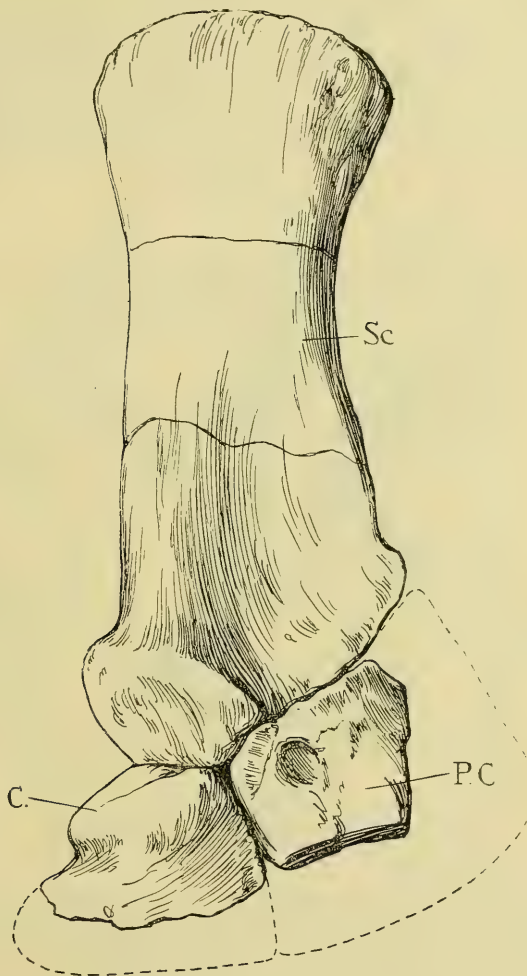
R. 1706 B.M.N.H.

Associated with the skull R. 3596 are several dorsal centra and one arch, three femora, all extremely similar, a tibia, and a humerus and atlantal intercentrum.

The atlas and axis of *Moschops capensis* have been described and figured by Broom, Bull. American Mus. Nat. Hist. vol. xxxiii. p. 139, fig. 5.

The anterior vertebræ are not well represented in the Museum collection, but have short deeply concave centra and massive arches with short transverse processes; the articular facet for the rib seems to be continuous and to be carried on the arch and

Text-figure 11.



Right scapula, coracoid and precoracoid of the type-specimen of *Phocosaurus megischion* Seeley,  $\times \frac{1}{3}$ .

The part of the scapula between the lines which cross it is restored. It is known from the evidence of other specimens that the length is approximately correct.

C., Coracoid; P.C., Precoracoid; Sc., Scapula.

centrum equally (text-fig. 10). The later dorsals have centra like those of the anterior vertebræ, but the rib-facet is high up and near the front border. The arches are high and massive and carry long transverse processes directed nearly horizontally. The zygapophysial articulations are flat and inclined to one another and the spines not very high.

The sacrum of *Phocosaurus* is composed of four vertebræ whose centra are fused. The sacral ribs are articulated with both centrum and arch; those of the anterior two vertebræ are very massive and of about the same size, the other two are much smaller. One interesting feature is that the distal ends of the anterior sacral ribs meet and fuse before they reach the ilium.

Text-figure 12.



Right humerus of the type of *Pnigalion oweni*,  $\times \frac{1}{3}$ .

The caudal vertebræ are very short, and the series belonging to the type of *Tapinocephalus* seems to taper rapidly, so that the tail was undoubtedly short.

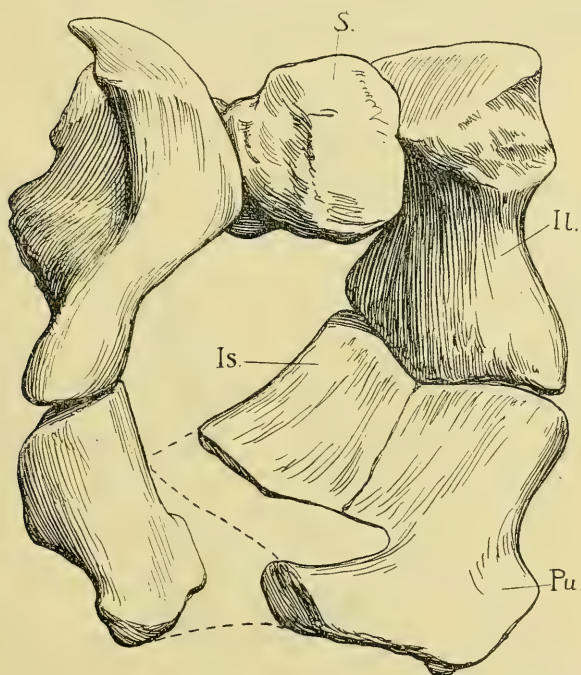
The shoulder-girdle of Tapinocephaloids seems to be very large and massive in comparison with the skull.

The scapula (Sc., text-fig. 11) is represented by its well-preserved lower and upper ends in *Phocosaurus* and by an isolated bone which gives the length. It has a flat blade with no indication of an acromial process. The lower end has a long, straight face for

articulation with the precoracoid. Behind this it thickens and forms the upper part of a glenoid cavity which looks outwards and slightly backwards.

The precoracoid (P.C., text-fig. 11) is a very large bone articulating by a long suture with the scapula and bearing a long articular face for the coracoid. It is pierced by a foramen which opens into a distinct pit on the visceral surface. The coracoid (C., text-fig. 11) is a large bone which has a long surface for contact with the precoracoid, and whose upper anterior corner articulates with the scapula. Behind this contact it forms the lower portion of the glenoid cavity, which is entirely formed by the scapula and coracoid.

Text-figure 13.



Sacrum and pelvis of the type-specimen of *Phocosaurus megischion* Seeley; seen obliquely from front.  $\frac{1}{2}$  nat. size.

Il., Ilium; Is., Ischium; Pu., Pubis; S., Sacrum.

The humerus (text-fig. 12) is a very massive bone with expanded ends which are in planes at a considerable angle to one another. The head is cylindrical and directly continuous with the enormous deltoid crest, which, after extending more than halfway to the distal end of the bone, suddenly subsides into the shaft. The

shaft is relatively slender but very short, and soon expands into the broad distal end. This is furnished with two articulating faces: one almost entirely represented by a low knob on the anterior face of the bone for the radius, the other on the end for the sigmoidal fossa of the ulna. There is a large entepicondyle, and a foramen piercing the shaft just at the end of the deltoid crest.

The ulna is a short massive bone, with a pronounced olecranon process and a facet for the head of the radius.

The pelvis of *Phocosaurus* (text-fig. 13) has already been described by Seeley, and its general character will be best understood from the figures of this paper. The interesting features are the small pubic foramen, the absence of any obturator foramen, and the enormous size of the acetabulum.

The four sacral ribs articulate with the inner surface by large facets, which are continuous with one another.

Text-figure 14.



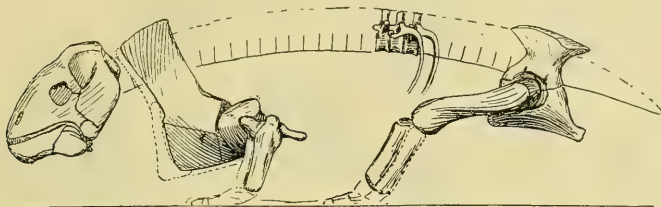
Left femur of the type of *Pnigalion oweni*,  $\times \frac{1}{3}$ . R. 3596.

The femur (text-fig. 14) is a very large bone with a rounded head and long and large external trochanteric ridge, which slowly subsides on to the shaft. The lower end is provided with two condyles, which are only obscurely separated from one another. The bone as a whole is flattened dorso-ventrally.

The tibia is a bone with very few features; it has an expanded head and a short, thick shaft.

The restoration of the skeleton (text-fig. 15) founded on all this material gives one an idea, which is probably generally correct, of the habit of the group. The striking features are the small head and very massive limb-girdles. *Phocosaurus* is relatively more heavily built than "*Pariasaurus*" *baini*.

Text-figure 15.



Restoration of the skeleton of a Tapinocephaloid.

Skull, humerus, femur, and tibia from the type of *Psigalion oweni*;  
other bones from the type of *Phocosaurus*.

#### *Dentition and Systematics of Tapinocephaloids.*

The type-specimen of *Tapinocephalus atherstonei* has been ground down so as to show many sections of uncut tooth-crowns and of the roots of functional teeth. Judging from these the teeth are similar all round the upper jaw, there being no enlarged canine.

The teeth-crowns, as shown by the series of sections which cut them at many levels, consist of a sharp upstanding cusp, the outer side of which is rounded and the inner side flattened; from the lower border of this cusp the crown is continued inwards on a large shallowly concave area surrounded by ridges descending from the sides of the anterior cusp; these seem to be smooth, and the outer is the larger. An isolated tooth (text-fig. 16, B) in the Museum collection seems to agree with the tooth-crown restored from the sections shown in this type-specimen.

R. 3594, which may be called

*Mormosaurus seeleyi*, gen. et. sp. n. (Pl. IV.),

has an extremely feeble dentition, which is quite uniform throughout so far as can be judged from the usually imperfect crowns and alveoli. Each tooth seems to consist solely of a cusp which is oval in section and has a coarsely serrated edge.

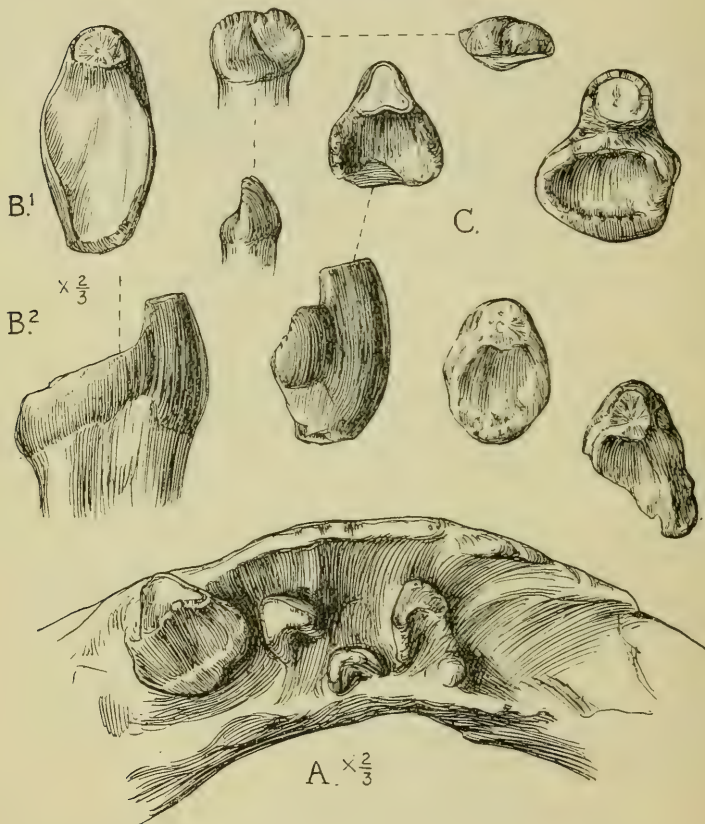
R. 3596 may be called

*Psigalion oweni*, gen. et sp. n.

The dentition of the upper jaw is not known, but there is no sign of an enlarged canine in the dentary. The teeth seem to be similar all round the mouth. Each tooth consists of a high

outer cusp with a rounded external surface and a deep groove down its inner side. All round the inner side and front and back of this cusp rises a strong cingulum, whose margin is raised and serrated so as to form a cup in the middle of the crown.

Text-figure 16.



Deinocephalian teeth.

A. Right dentary of type-specimen of *Prigalion oweni*,  $\times \frac{2}{3}$ .

B. *Tapinocephalus*?,  $\times \frac{2}{3}$ .

C. Series of teeth of one individual of unknown genus,  $\times 1$ .

No. 49385 may be called

*Lamiasaurus newtoni*, gen. et sp. n.

The dentition of the upper jaw consists of four large incisors represented only by their alveoli, which are oval in shape and

suggest that the teeth may have been like those of *Deuterosaurus*.

There is a single canine, which is large, strongly inclined forwards, and circular in section. Behind this there are three molars, shown in transverse section to be circular and relatively small; it is probable that there was one more only.

One important difference between this type and the preceding three is that whilst they all have very numerous replacing teeth, which are not in the same stage and were thrust up indefinitely like those of a crocodile, in *Lamiasaurus* there is no trace of successional teeth.

The other types of South African Tapinocephaloids which have been described are:—

*Delphinognathus conocephalus*, a much smaller form without large canines, of which the details of the dentition are not known.

*Moschops capensis*, also a small form with no canines and with no details of the dentition.

*Taurops macrodon*, a large form apparently with teeth somewhat like those of *Tapinocephalus*, but not sufficiently described or figured to be definitely identified at present.

*Eccasaurus priscus*, founded on a humerus of rather unusual type, to which is referred a tooth of the general plan of *Tapinocephalus* but of a narrower oval form and more cuspidate.

*Moschognathus whaitsi*, founded on a figured lower jaw which, as it seems to contain no teeth, is indeterminable.

The Titanosuchid branch of the Deinocephalia is represented by the following skull-material in the British Museum (Natural History):—

An imperfect skull (Pl. V., & text-figs. 17, 18) consisting of the dorsal surface from behind the nostrils to the back, with the squamosals and part of the zygomatic arch; and a block which has a rather poor fit with the upper part, but contains a good deal of the maxilla and prevomers and a small fragment of the palatine.

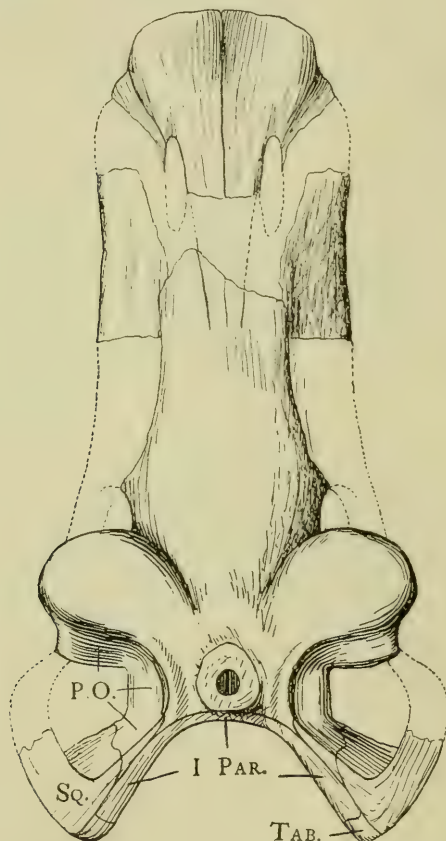
This specimen (R. 3595) was collected by Prof. Seeley at Tamboer Fontein. The only other skull-materials I have used are the premaxillæ of the type-specimen (49370), which itself consists of the associated remains of two individuals of identically the same size. The maxillæ of these agree exactly, so far as can be seen, with that of the specimen mentioned above.

Nothing is known of the basicranial part of the skull, but the supraoccipital above the post-temporal fossæ is present in the Tamboer specimen. It is a flat wide plate with rather large post-temporal fossæ bounding it below, and the upper part of the deep and narrow brain-cavity impressed on its lower surface. Its posterior surface is overlapped by the interparietal and tabulares, and its upper edge is in contact and perhaps fused with the parietals.

A small part of the ethmoid remains in contact with the under surface of the frontals, and is a small bone with a very small cavity for the olfactory lobes of the brain.

The interparietal (I. PAR., text-fig. 17) is a very large vertically placed plate on the back of the skull. Its anterior face is in contact with the upper part of the supraoccipital and the posterior ends of the parietals. Laterally it overlaps the parietal rami of the postorbital and squamosal and the tabulare.

Text-figure 17.



*Titanosuchus*. Dorsal aspect of skull. Premaxillæ from type.

The remainder from R. 3595 B.M.N.H.  $\times \frac{1}{6}$ .

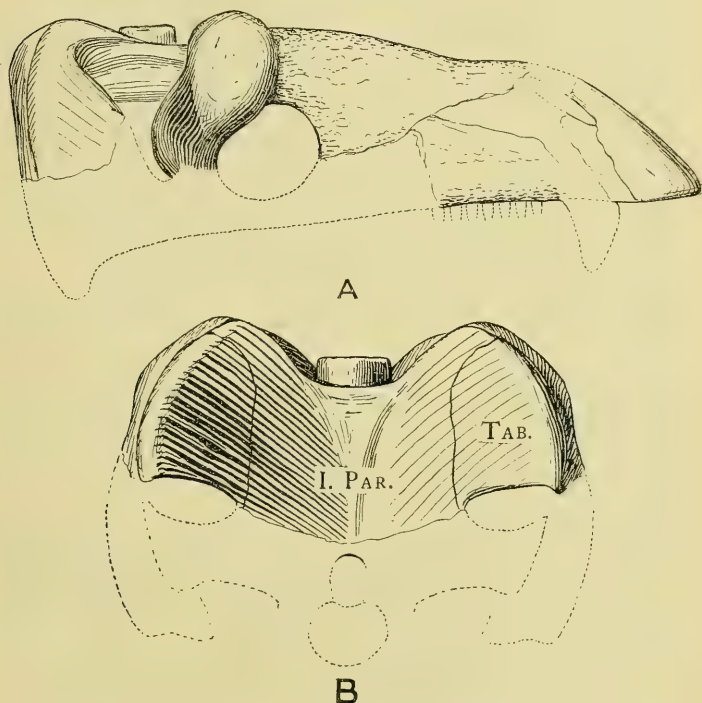
P.O., Postorbital; SQ., Squamosal; I.PAR., Interparietal; TAB., Tabulare.

The tabulare (TAB., text-figs. 17 & 18 B) is a large bone, whose medial border is covered by the interparietal and whose

anterior face has a contact with the supraoccipital, postorbital, and squamosal. Its lower border forms the upper side of the post-temporal fossa, and its outer edge is thickened and with the squamosal forms a long, vertically placed auditory groove.

The squamosal (Sq., text-fig. 17) is only incompletely preserved; as shown it has a parietal ramus, which covers much of the front face of the tabulare and extends inwards to overlap the posterior end of the postorbital. With the tabulare it forms the auditory groove on the postero-lateral corner of the skull, and beyond this sends forwards a massive zygomatic part on the outer surface of the skull.

Text-figure 18.



A. *Titanosuchus*. Lateral aspect of the same specimen as text-fig. 17.

B. *Titanosuchus*. Posterior aspect of skull. B.M.N.H.  $\times \frac{1}{5}$ .

I. PAR., Interparietal; TAB., Tabulare.

Except for the suture with its fellow and the frontal, the parietal is completely shown. It is a small bone in contact with its fellow except for the pineal foramen, which is a round hole. The two bones form a special little projection raising the opening more than a centimetre above the general line of the surrounding bone.

The sutures surrounding the postorbital (P.O.) are all visible, but that with the postfrontal only on the ventral surface. The bone forms a massive sheet at the back of the orbit, and forms the hinder part of the extraordinary mass of bone which overhangs it; it sends back a powerful process along the side of the parietal, which forms the inner border of the temporal fossa, and thence runs outwards along the front face of the tabulare to be covered by the squamosal.

The sutures separating the postfrontal from the postorbital and prefrontal are only visible on the under surface; they are straight and run inwards for a very long distance with the postfrontal as a narrow strip between them. It probably forms a good deal of the knob above the orbit.

The sutures between the prefrontal and lachrymal etc. are not visible, but on the under surface it seems that the nasals are narrow bones, each carrying a sharp-edged rib, so as to form a groove on the lower surface.

At the anterior end the specimen shows on the outer surface traces of the sutures between the internarial processes of the premaxillæ and the nasals. It is evident that they were very long.

The premaxillæ known from the type-specimen have a flat facial surface and rather broad internarial processes, the nares being on the dorsal surface some distance behind the snout.

The palatal surface of the premaxilla is entirely formed by its tooth-bearing edge, and the lateral border is in contact with the maxilla.

The maxilla is a large bone with a great facial expansion. Its palatal exposure is solely formed by its dentigerous margin, and it is in contact with the palatine. There are large prevomers with a long interchoanal bar, the dorsal surface of which rises into a high thin flange. Of the quadrate only the articular edge is known, which gives no indication of its size.

The type-specimen of *Titanosuchus ferox* gives many bones of the lower jaw, all disarticulated. The articular is a small bone with a cotylus for the quadrate condyle, which apparently faces very nearly backwards. The postarticular part is only represented by a small process on the lower side of the bone. The anterior part rapidly narrows and finishes in a point. There are well-marked articulating surfaces for the prearticular and surangular. The angular is flat, and has a deep and very narrow notch covered with a reflected lamina exactly as in a Gorgonopsid. The dentary is a very massive bone, with a deep groove on its inner surface for the prearticular, surangular, and angular. The bone seems to give evidence that there was no freely projecting coronoid process. One interesting feature is that there is a very shallow, but quite definite, step in the dentigerous margin behind the canine, as in Gorgonopsids, but, of course, relatively very much smaller.

The lower surface of the dentary has a broad surface for the splenial, which must have formed the whole of the lower border of

the anterior part of the jaw, and had a large symphysis with its fellow.

The post-cranial skeleton of Titanosuchids is represented by two series of bones:—

The type-specimen of *Titanosuchus ferox* (two individuals): neural arch and intercentrum of atlas, vertebræ, scapulæ, coracoid, cleithra, clavicle, three humeri, femur, and fibula.

A series of associated bones of another genus, comprising vertebræ, ribs, ilium, humerus, femora, tibia, and skull-fragments.

The atlantal neural arch is absolutely identical with that of the Dicynodont *Kannemeyeria*, as is the intercentrum. They give evidence that the whole complex was similar to that of *Moschops*, as described by Broom.

The vertebræ of *Titanosuchus* are all extremely unsatisfactory, but seem to be generally similar to those of Tapinocephaloids, with longer neural spines and shorter transverse processes; it is just possible that the capitulum and tuberculum were connected by a very thin web.

The other specimen has very high neural spines.

Certain fragments of bone belonging to the type of *Titanosuchus* suggest the presence of relatively feeble abdominal ribs.

The scapulæ are very much weathered, but are extremely large and massive bones, giving no evidence of an acromion.

The coracoid is essentially identical with that of the Tapinocephaloids, and shows clearly that the precoracoid was excluded from the glenoid cavity.

The cleithrum is a fine bone, nearly 8 centimetres wide and 2 thick; it has an articular facet for the front edge of the scapula.

What is almost certainly the lower end of the clavicle is represented by an unsymmetrical sheet of bone about 20 cm. by 30 cm., which has the root of a powerful process arising from one surface just within the edge. There is no other bone in the skeleton it can possibly be, and, if it is correctly determined, the interclavicle must have been an extraordinary wide flat sheet.

The humerus as figured by Seeley, Phil. Trans. 180 B, pl. xx. figs. 1 & 2, gives a rather misleading idea of the bone. It is in essentials much like that of the Tapinocephaloids, but differs in its relatively narrower lower end, in having the facet for the head of the radius still more on the front of the bone, and the two openings of the entepicondylar foramen on the same side of the shaft. Finally, there is a small ectepicondylar foramen.

A single ulnare is present in the material; it is a rather small but thick bone with a notch in one border, forming part of the ordinary foramen between the ulnare and the intermedium.

The ilium is very incomplete, but is a short bone, apparently similar to that of the Tapinocephaloids.

The femur differs from that of the Tapinocephaloids in its relative slenderness and the lesser size of the trochanter.

The tibia does not differ essentially from that of Tapinocephaloids.

*General Discussion.*

That the animals whose structure I have discussed under the heading of Tapinocephaloids are all closely allied admits of no discussion, and is self-evident in every detail of their structure.

To the same group belongs the Russian type *Deuterosaurus*. As shown clearly by Eichwald's figures, the dentition is absolutely characteristic, the powerful incisors which interlock are structurally identical with those of *Tapinocephalus*. The enlarged canine so clearly shown in his figures occurs in the remarkable type *Lamiasaurus* which I have described above, and the presence of only a single molar is a variation of slight importance. The skull figured by Prof. Seeley has all the characteristic features of the group, the broad zygomatic arch with the postorbital obviously widely meeting the squamosal and the covering of the side of the parietal by the postorbital (as shown and lettered "post-frontal" in Seeley's figure) being identical with the structures in the South African forms. Even the slight difference in the narrowness of the intertemporal bar and the crest on the parietals can be matched in a fragment from South Africa in the British Museum. Seeley's figure also seems to show that there was the very characteristic vertical area of basioccipital below the condyle and the large quadrate characteristic of the group.

The Russian type *Rhopalodon* and that described by Twelve-trees as *Clorhizodon orenbergensis* (R. 4077), which is perhaps generically identical with the previously described *Deinosaurus*, are apparently closely allied to *Titanosuchus*. *Clorhizodon* (at any rate, as shown by the beautifully preserved type-specimen in the British Museum) is extraordinarily like a small *Titanosuchus*, as was, in fact, recognised in the original description. There is nothing in the whole structure of the skull to prohibit a connection.

Whether *Titanosuchus* is really closely allied to the Tapinocephaloids, or whether it is a specialised Gorgonopsid, as Broom now believes, is perhaps more doubtful. It resembles the Tapinocephaloids in the extraordinary thickening of its skull and in the whole texture of all the bones.

The whole structure of the temporal region, the form of the squamosal, and the relations of the tabulares (postorbitals, parietals, and squamosals) are identical in the two types. The very curious auditory groove is the same in each type. The premaxillæ of *Titanosuchus* have a thoroughly Tapinocephaloid appearance, and the position of the external nares far behind the end of the snout on the dorsal surface is unparalleled in Therapsids, except in that group.

If *Rhopalodon* is indeed related to *Titanosuchus*, then in the large quadrate and the vertical area of basioccipital below the condyle we have very striking resemblances to the contemporary Tapinocephaloids.

Finally, so much of the palate of *Titanosuchus* as is known is quite unlike that of any Gorgonopsid, whilst it strikingly resembles in detail that of *Lamiasaurus*. We are, I think, therefore justified in regarding the two as divergent branches of the great order Deinocephalia.

That the Deinocephalia are Therapsids has never been questioned of recent years. The whole character of the limb-bones, particularly the humerus, is quite like that of the corresponding parts of an Anomodont, and is unknown in any other group. The shoulder-girdle with the precoracoid excluded from the glenoid cavity is extremely like that of a Gorgonopsid, and, except for its lack of an acromion, that of *Dicynodon*. No similar arrangement is known in any other group of reptiles. In the more fundamental features of its skull-structure, the wide occipital plate with the small and greatly separated post-temporal fosse, the high brain-cavity, and the low position of the vestibule of the ear, it agrees exactly with all South African Therapsids. As is shown clearly by Dr. Broom's figures of the lower jaw and by that of *Titanosuchus*, it has the characteristic flat angular and notch of the Therapsids.

The group has, however, a very special importance, because alone amongst the South African forms it retains a large quadrate. The Tapinocephaloid quadrate is relatively as large as in any other reptile—as large, for instance, as that of a Tortoise. The importance of this is that it shows that the reduction of the quadrate, which is so noticeable a feature of the Anomodonts and “Carnivorous” Therapsids, is not an essential feature of Therapsid structure, but has developed in comparatively late times in at least two branches independently (I intend to adduce evidence in support of this statement in a later paper). Some years ago, in describing the skull of *Diademodon*, I pointed out that this reduction of the quadrate was part and parcel of a whole series of changes which led to the reduction of all regions of the skull (the basisphenoidal, basioccipital, and exoccipital regions in particular) which lay below the base of the brain. This generalisation is justified by all subsequent work on Therapsids, and is well illustrated by the great depth of the basicranium in Deinocephalia, an arrangement which may to some extent be paralleled in Dinosaurs.

The exact relation of the Deinocephalia to other South African groups of Therapsids is not easily determined.

The skull of *Titanosuchus* bears a very considerable resemblance to that of a Gorgonopsid, modified, of course, by its great thickness and the large bony bosses over the orbits. It is distinctly more primitive in many features—for instance, in the less widely spread zygomatic arches. The skulls of the more primitive Gorgonopsids, however, show no trace of the vertical area of basioccipital below the condyle; and there are no features of the auditory region of the brain-case which in any degree suggest that they have been derived from a type with a Deinocephalian

structure. It will be remembered that *Rhopalodon*, which is in many ways extremely like a Gorgonopsid, has this characteristic Deinocephalian structure. So far as the lower jaw goes, the Gorgonopsids could be derived directly from a lightly built Titanosuchid. The post-cranial skeleton, so far as is known, is also very similar, allowing for the differences due to the great weight of all well-known Deinocephalians or, using as a term of comparison, the relatively slender bones from the Ural copper-mines.

In fact, it is legitimate to assume that Deinocephalia and the Gorgonopsids arose from a not very distant common ancestor, but that they subsequently pursued quite different paths.

Perhaps the most interesting comparison is with the Anomodonts. In many features (the upturned parasphenoid and the structure of the ethmoid, for example) there is a distinct resemblance between the two groups, which also resemble one another to some extent in the shortness of the brain-cavity—in some types, at any rate. Further, many Anomodonts have a considerable vertically placed area of bone below the basioccipital condyle, which may be compared with that in Tapinocephaloids. As this area does not exist in *Endothiodon*, whilst it is most pronounced in *Lystrosaurus*, it is probably a secondary specialisation independently acquired within the group. Connected with this feature, however, is the development of that curious process of the vestibule which carries the fenestra ovalis down to the lower border of the skull. This curious detail is found even in *Endothiodon*, a rather primitive type, and is apparently quite a fundamental character of the group.

Although the cavity of the inner ear has not been cleared in any Deinocephalian, there can be no doubt that a similar structure did occur in that group—a fact which suggests a nearer relationship between the two groups than either of them hold with the Gorgonopsid line.

At the same time the Deinocephalia differ from all other South African Therapsids in the mode of articulation of the ribs in the dorsal region.

The most interesting comparison is between the Deinocephalia and the Pelycosauria, using that term to cover all the "Texas" Therapsids.

If we compare a Deinocephalian with the very primitive *Varanosaurus*, we find many resemblances. We have, to begin with, the characteristic Therapsid characters of the occiput and lower jaw. In addition, we find that there are striking resemblances between the quadrates of the two types in their size, relation to the squamosal and quadratojugal, and in the powerful step for the distal end of the stapes. Another resemblance is in the form of the squamosal, which in both types is a simple sheet folded round the back of the quadrate, and not produced outwards as in the Anomodonts and Therocephalia. The occurrence of a

vestigial "supratemporal" in *Varanosaurus* is a primitive feature of little importance.

Comparison of a Tapinocephaloid with *Dimetrodon* leads to some interesting results, as Broom has already pointed out. There is a resemblance in shape, owing to the very short temporal regions and high and compressed form of the skull in both groups. The basicranial region of *Dimetrodon*, although more specialised than that of *Varanosaurus*, shows no suggestions of the characteristic Deinocephalian structure, and is, in fact, extremely like that of the more primitive of the Gorgonopsids. The very peculiar parasphenoid is identical in the Deinocephalia and *Dimetrodon*, and it is probable that the ethmoids are also similar. The quadrate of *Dimetrodon* is modified from its primitive condition by that development backwards of the posterior angles of the skull which is shown by the curious backwardly directed processes of the outer ends of the paroccipital processes. Making allowance for this modification, its relations to the surrounding bones are essentially those held by the corresponding bone of *Mormosaurus*, so far, at any rate, as can be judged from published descriptions. In the palate also there are distinct resemblances in the development of the high vertical flanges from the pterygoids and prevomers. The two types are, however, specialised in directly opposite directions, one with a short face for a herbivorous diet, the other with the elongated gape which is necessary to a carnivorous animal with the characteristic reptilian habit of grasping its prey after a single snap.

The occiput of *Edaphosaurus*, as figured by Williston and Case, is extremely like that of *Psigalion*, and, if we may judge by *Varanosaurus*, was essentially similar in structure.

Finally, as Broom has pointed out, the face of *Dimetrodon* is structurally very similar to that of such a Deinocephalian as *Mormosaurus*—it is perhaps even more similar to that of *Deuterosaurus*.

On the whole, the Deinocephalian skull resembles that of the Pelycosaur more closely than it does any other South African Therapsid.

As Broom has already shown, the lower jaw of a Tapinocephaloid, except for the differences due to the oppositely specialised dentitions, is structurally very similar to that of *Dimetrodon*. It differs, however, in the more greatly developed Therapsid notch.

Broom has already shown the very striking resemblance between the Pelycosaur vertebræ (particularly those of *Dimetrodon*) and those of Tapinocephaloids.

In the rest of the post-cranial skeleton, however, there is very much more similarity between the Tapinocephaloids and the other South African Therapsids than between that group and the earlier Pelycosaurs.

In the cartilaginous shoulder-girdle the precoracoid is entirely

excluded from the glenoid cavity, and there is no trace of the screw-shaped form of the articular surface which is an essential feature of the primitive type. The humerus also is of a more modernised form, its action being an up and down movement instead of one which is nearly parallel to the ground. The very broad lower end of the clavicle of *Titanosuchus* is, however, a point of resemblance with the earlier forms.

In the pelvic limb we find a somewhat similar mixture of characters.

The whole pelvis, for example, is somewhat similar to that of *Dimetrodon*, particularly in the production of the outer corner of the front border of the pubis and its deflection, more so perhaps than to any South African type; but the femur is of a modernised type strongly resembling that of *Dicynodon*.

The final result is that the presence of the Deinocephalia makes it impossible to exclude the American Lower Permian and Carboniferous Pelycosaurs from the later South African Therapsids. Such a division could at any time have been drawn only on the more primitive limbs and large quadrate of the early forms; the fact that in Deinocephalia we have types with a quadrate as large as that of the Pelycosauria combined with modernised limbs renders the foundation of a great group-division on these characters quite impossible.

For this great stem of the Reptilia, including all the mammal-like reptiles, many names are available. I am myself inclined to extend Broom's Therapsida, a most appropriate name, to the whole of them, but I fully recognise that Cope's earlier names of Theromorpha and Theromora have been used in the same sense; these names were never very clearly defined by Cope, and have at one time or another included nearly all Permian reptiles. If anyone should wish to resuscitate these names in this connection, I would point out to them that Owen's term Anomodontia was used by that author in 1860 in a wide sense to include the Dicynodonts and also carnivorous Therapsids from South Africa, and has at least as good a claim to be used as Cope's later terms.

#### *Discussion of Special Features of the Skull.*

The septomaxilla of Deinocephalia is of interest on account of its variability. It resembles that of all other Therapsids, except certain Cynodonts and Anomodonts, in the fact that there is a foramen behind it opening from the outer surface into the nasal cavity. It is of interest that this foramen was first described by Case in *Dimetrodon*. It is evident in the majority of the more primitive South African "Carnivorous" Therapsids, and is clearly shown in a British Museum skull of *Endothiodon* and in Prof. Sollas's model of *Dicynodon*. Its function is unknown, the only suggestion I have yet found is that it may mean that the ductus naso-lachrymalis opened on the surface; it will be remembered that in the small Temnospondylous Stegocephalian

*Micropholis* this duct runs forwards completely in the lachrymal bone to the posterior end of the septomaxilla, and it appears from its mode of development to have been primitively a mere surface-groove.

The squamosal of *Deinocephalia* is of some interest; in its relations to all other bones, particularly those of the otic capsule, the quadrate, tabulare, postorbital, and parietal, it agrees exactly with the corresponding bone of the more primitive *Gorgonopsids*, which is clearly identical with the squamosal of *Diademodon*, which is clearly homologous with the bone of the same name in Mammals. The squamosal of a *Deinocephalian* is clearly the same as the large temporal element in *Varanosaurus*, having similar relations to the paroccipital, postorbital and tabulare, and only differing in retaining its primitive connection with the pterygoid. As this type retains a small "supratemporal," there is now no doubt that the squamosal is the outer of the three temporal bones in primitive Reptilia.

#### *The Auditory Arrangements of the Therapsids.*

Of recent years belief in the truth of Reichert's hypothesis of the homologies of the mammalian ossicula auditus has been gradually growing, and the fine work of Gaupp has practically placed it beyond question. At the same time, Broom, following a suggestion of Seeley's, has shown how in the gradual increase in size in the dentary and the decrease of the other elements of the jaw and the quadrate, the "carnivorous" Therapsids gradually approach the mammalian condition. The same author has pointed out that the stapes is articulated with the quadrate in Therapsids just as is the stapes of mammals with the incus. Finally, following on my own more accurate account of the Therapsid jaw, Mr. Palmer has shown the extraordinary similarity in detail between the lower jaw (including the dentary, malleus, pre-articular, and tympanic) of a mammary foetus of *Perameles* and that of the advanced Cynodont *Diademodon*.

The homologies of the various bones being now placed beyond dispute by the work of these authors, it is desirable to carry the inquiry further and discuss the position and changes of the tympanic membrane and other parts of the ear.

The stapes of Therapsids is in all cases where the condition is known articulated with the quadrate. In the following types, *Cynognathus*, *Trirachodon*, *Nyctosaurus*, *Arctognathus*, *Lycosaurus*, *Dicynodon*, *Lystrosaurus*, *Dicelurodon*, *Kannemeyeria*, *Mormosaurus*, *Prigalion*, *Lamiasaurus*, *Dimetrodon*, *Varanosaurus*, which cover the superorder very fairly, the stapes has actually been seen in place; the facet on the quadrate for its distal end is shown in very many more forms.

Quite recently, when discussing the primitive Therapsid *Varanosaurus*, I pointed out that in many ways it greatly recalled the

Cotylosaurian family of the Captorhinidæ, so much so that a blood-relationship between them seemed most probable.

Prof. Williston had still earlier expressed a similar opinion:—"That we have in *Labidosaurus* and its allies a persistence of those generalized characters which gave origin to the peculiar specializations of the Pelycosaur." One of the peculiarities of these Captorhinids, in which they differ from all other known Cotylosaurs, is the fact that they have a stapes whose distal end is articulated with the quadrate. We have therefore some justification for assuming that this peculiar condition in the Therapsids has not arisen within that group, but has descended to it from its ancestors.

I have shown that there are very strong reasons for believing that the reptiles have arisen from the embolomorous Stegocephalia, which are the only group of Tetrapods known in Lower Carboniferous rocks. In figure A, in the plate of my paper on "The larger Coal-Measure Amphibia," Manchester Memoirs, vol. lvii. pt. i., there is shown a very definite depression on the upper surface of the quadrate and pterygoid. This definite pit occurs in all embolomorous Stegocephalia in which I have examined this region, and is obviously of importance. The only explanation I can find for it is that it received the outer end of the stapes. It is important to note that in the uncrushed skull it must have looked towards the auditory region. There is thus a suggestion of evidence that the Cotylosaurs of the family which gave rise to the Therapsids and the Captorhinids received the condition of having the distal end of the stapes articulated with the quadrate from their amphibian ancestors, as they in turn passed it on to their descendants.

There are strong reasons for believing that the Stegocephalia have arisen from the Rhipidistian group of the Crossopterygian fishes (the Osteolepids), which were no doubt technically, though probably only to a slight extent, functionally hyostylic. In these fishes the hyomandibular, which has been seen only by Dr. Traquair in *Rhizodopsis* (an observation I have been unable to check from the material in the British and Manchester Museums, which includes at least the greater part of that which was before Dr. Traquair), no doubt articulated with the otic region of the cranium and with the quadrate, as in all fishes. There are many reasons for believing that the stapes of a Tetrapod is homologous with the hyomandibular of a fish, and it is probable that in the embolomorous Stegocephalia, which had just arisen from fishes, the primitive connection between the distal end of the hyomandibular or stapes and the quadrate was retained. In later Amphibia (*Eryops*, *Trimerorachis*, *Cyclotosaurus*, to mention only types in which it is known in place) it lost this connection, and its distal end is connected with a tympanic membrane stretched across the otic notch.

It thus seems to be fairly probable that the connection between the distal end of the stapes and the incus in a mammal has been

directly derived from the connection of the distal end of the hyomandibular and the quadrate in its far-off fish-ancestor, and that this connection has never been lost in the phylogeny of the group.

The most primitive lower jaw known amongst Therapsids, that of *Dimetrodon*, as it has been described and figured by Case, Williston, and Broom, is differentiated from that of a member of any other Reptilian superorder by the characters of its posterior part, and particularly the angular. In *Dimetrodon* the angular is essentially a flat plate whose upper border overlaps the surangular and is itself overlapped by the dentary in the usual way, whilst its lower border forms the lower border of the jaw. The posterior end of this bone is separated from the outer side of the prearticular by a notch, so that the border stands out freely. The whole jaw is very narrow from side to side, the Meckelian vacuity being reduced to a very narrow slit between the prearticular and the surangular. The flat plate-like angular and the notch in its posterior border are the characteristic features of this jaw, and are found in all Therapsids which are properly known and in no other reptiles whatsoever.

The Deinocephalian jaw only differs from that of *Dimetrodon* in the further enlargement of the notch, which in this type extends forwards so as to form a deep pocket in the substance of the angular. In such Therocephalians as *Scylacosaurus* the condition of the angular is almost exactly as in Deinocephalia, there being a deep but very narrow pocket in the substance of the angular which forms a large reflected lamina outside it. The foramen shown in the angular in many of Broom's figures of Therocephalian skulls has no existence in fact, as such, but is merely the anterior end of the notch.

In the Gorgonopsids there is the usual notch and reflected lamina, which is, however, small, never reaching the size of that of *Scylacosaurus*. This notch in the higher Gorgonopsids, *e. g.* *Arctognathus*, seems to move relatively further forward. Finally, in the Cynognathids, which have a "look" of the Gorgonopsids, of a character that cannot be intelligibly expressed in words but is very striking to anyone accustomed to handling the two types, and suggests that they are in all probability genetically related, the notch has moved still further forward, and the reflected lamina now stands downwards from the rest of the bone as a very slender process. The extraordinary resemblance of this bone to the tympanic of the pouch fœtus of *Perameles* (or of *Dasyurus*) seems to me to raise a very strong case for believing that *Cynognathus* and its allies had a tympanic membrane spread between the divergent branches of its angular. The actual shape of the bone makes such a position possible, the hinder end of the membrane being carried by the ridge on the lower side of the squamosal, which lies just outside the end of the paroccipital process, and on the musculus depressor mandibuli, if such a muscle be present. A membrane in this position stands nearly

vertically in the skull, and lies at the lower and inner end of the groove which Broom and I, following the original identification of W. K. Gregory, regard as an external auditory meatus. If this position was really that held by the tympanic membrane in *Diademodon*, then in that type the tympano-tubal cavity had already grown up round the bones of the back of the lower jaw. If this position of the membrane be correct, by tracing back along the series of Gorgonopsids to the Deinocephalia, we ought to have self-consistent results throughout, and to arrive at a condition in primitive forms which is not inconsistent with that found in known Reptilia. The series of Gorgonopsids at my disposal gives a sufficiently close morphological series to show with certainty that:—

- 1st. The notch in the hinder border of the angular of a Deinocephalian is homologous with the wide triangular notch in *Diademodon*.
- 2nd. That the very small but distinct auditory groove described above in Deinocephalia is homologous with that of *Diademodon*.
- 3rd. That the ridge to the outer side of the paroccipital on the squamosal in the two types is the same.

These homologies lead us to expect that the tympanic membrane of Deinocephalia should be attached to the squamosal just outside the paroccipital process, to the posterior surface of the quadrate, and to the edge of the reflected lamina of the angular. I believe such an attachment to be workable inasmuch as a tympanic membrane attached to it might be flat.

The groove for the external auditory meatus in Deinocephalia is of great interest. It is undoubtedly homologous with that of *Diademodon*, and I think almost as certainly with that of a mammal. It gives clear evidence that even at this time the tympanic membrane (whatever its precise situation and attachments) had sunk in and was no longer directly exposed on the outside of the head. It is formed by a groove between the outer edge of the tabulare and the squamosal; this groove terminates suddenly where the tabulare ends in a definite projection from the back of the skull which must mark the upper insertion of the membrane.

It is known from the evidence of specimens which show the complete stapes in position—*Eryops*, *Trimerorachis*, *Cyclotosaurus*, etc.—that in Stegocephalia the tympanic membrane was stretched between the tabulare and the squamosal across the otic notch on the upper surface of the skull. By direct tracing back of homologous parts we have seen that in Deinocephalia the upper end of the membrane should be attached to the squamosal and the extreme distal end of the tabulare: that is, in the exact position we know it to have been attached in Stegocephalia related, although remotely, to the Deinocephalian's amphibian ancestors.

It will be convenient here to leave this particular line of argument, and starting from the normal conditions of the membrana tympani in Reptiles, try to reconstruct the arrangement in *Dimetrodon*, and so work back to the termination of our original argument at the Deinocephalia.

In Lizards the insertion of the tympanic membrane is on to the back of the quadrate, the squamosal just outside the paroccipital process, and the retro-articular portion of the lower jaw.

In Pelycosaur and other Therapsids the retro-articular portion of the lower jaw is of insignificant proportions, at its largest in *Dimetrodon*. In Deinocephalia and *Dicynodon* it is represented solely by a small process from the articular directed as much downwards as backwards. The definite presence of this process in these more primitive forms and its still further reduction in later types, seem to show that some Therapsid ancestor had a relatively large retro-articular process. As in all reptiles which have such a process its outer side is covered by the angular, we may assume that in this hypothetical ancestral Therapsid the retro-articular portion of the angular played some part in the support of the tympanic membrane. If now in such an animal we make the tubo-tympanic cavity grow forwards and the membrane to keep pace with it in such change, we must also move forward the upper edge of the retro-articular part of the angular to which the membrane is attached. As it is essential to keep the stretched membrane clear of other bones, and the articular and quadrate are by hypothesis fixed, we can only do so by separating the edge of the retro-articular part of the angular from other bones and moving it slightly outwards: this on the theory which I am at present expounding is the origin of the Therapsid notch, the upper edge of the reflected lamina being phylogenetically the upper border of the retro-articular portion of the angular, and retaining that connection with the lower edge of the membrana tympani which occurs in Lizards. By this method we arrive at a position of the tympanic membrane in Deinocephalia identical with that deduced by tracing the conditions down from Cynognathids, the arrangement in which was determined by assuming that the great resemblance between the angular of these types, with their long, slender, downwardly directed "reflected lamina," and the tympanic of a pouch-young of *Perameles* with its slender lower limb, was a real one. The fact that it is possible to trace a sequence of stages with only very few hypothetical intermediates between the actual condition of the membrana tympani in lizards and that in embryo mammals, and that these stages are in the correct time order, and are each self-consistent, seems to me to establish a probability that the assumption on which they depend, i. e. that the reflected lamina of the Therapsid angular carried the tympanic membrane, is a justifiable one.

I am quite aware that the shape of the edge of this lamina in some types, as for example in *Endothiodon* and *Anomodonts* generally, is inconsistent with the view that it carried the

membrane, but as in all these types the squamosal never shows any suggestion of an auditory groove or of the attachment of a membrane, I think it possible that they were without one, a not unknown condition.

In 1910 W. K. Gregory, from the position of the auditory groove in *Cynognathus*, inferred that the tympanic cavity and membrane were below the reduced quadrate and articular. From these relations and the fact that in the ontogeny of a mammal the tubo-tympanic cavity grows up round the auditory ossicles which arise outside it, he suggested that phylogenetically this upgrowing of the tubo-tympanic sac around the vestigial quadrate and articular may have caused them to share in its vibrations, and thus to take on an incipient auditory function before their old suspensory function had ceased.

This is exactly the conclusion to which the above discussion, founded mainly on quite different evidence, has led us.

In mammals the centre of the tympanic membrane is placed in connection with the chain of auditory ossicles by the handle of the malleus being fastened to its middle layer. In no Therapsid that I have yet examined is there a process of the articular which could touch the membrane, so that it is inherently probable that the manubrium is a mammalian innovation. In ontogeny it arises very late, chondrifying much later than the incus and body of the malleus in *Perameles*, but being apparently a real part of the latter bone.

It thus seems impossible that the membrane of Therapsids should be brought into connection with the fenestra ovalis in the ordinary mammalian way, and as the whole of the preceding arguments are meaningless if they have no membrane, it seems certain that another connection between the stapes and the membrane must have existed.

In a remarkably able and suggestive paper, Dr. Gregory has put forward the following explanation:—

“That in the most primitive Cynodonts, such as *Baweria*, there was an extra-columella, resting against a tympanic membrane behind the squamosal, which had been differentiated out of the tissue lying between the endodermal epithelium of the tympanic cavity and the epidermis: that with the spread of the tympanic cavity the differentiation of the future tympanic membrane also spread, until it included the stretched skin on the posterior end of the jaw below the quadrate and articular and above the angular: that concomitantly with the reduction of the quadrate and articular and the detachment of the angular and goniale from the dentary, the newly differentiated portion of the tympanic membrane became functionally more active than the old ‘reptilian’ portion: that in this way the old membrane together with the extra-columella became vestigial, while the new membrane became altogether free from the dentary, but remained fastened both to the angular, which gave rise to the tympanic bone, and to the retro-articular process of the articular, which gave rise to

the manubrium of the malleus. With the reduction of the 'reptilian' tympanic membrane the hyoid became separated from the extra-columella (as it does in many lizards) and migrated to a new insertion on the periotic."

The foregoing discussion will have shown how much of truth there may be in this brilliant hypothesis of Gregory's. The suggestion that the stapes of Therapsids although directly articulated with the quadrate may have been connected with the membrane by an extra-columella, is exactly paralleled by the actual conditions in Mosasaurs, where the slender stapes is inserted into a deep pit on the inner side of the quadrate, but is connected with the tympanic membrane by a process passing through the large special notch on the back of that bone. This process like the membrane is sometimes strongly calcified. The whole arrangement is after all only a further development of conditions commonly found in lizards.

The facts as we know them in *Diademodon*, or rather the interpretations of those facts offered above, show that the reptilian portion of the tympanic membrane had actually been reduced to very small dimensions by a steady process connected with and no doubt induced by the same factor as the degeneration of the quadrate and the thinning of the basisphenoid and basioccipital.

The facts also seem to show that the manubrium mallei is altogether a new formation, developed whilst the articular was losing its suspensory function.

If the explanation of the meaning of the observed series of changes in the articular region of the skull of Therapsids which has been presented above be true, or even if it contains but a small element of truth, it presents us with a good illustration of the fact, to my mind patent in the development of every organ of the body which is known, that the Therapsids from the moment of their initiation were committed to the final development of a mammalian structure. Different branches of them proceeded with their modifications to different degrees, and at very different speeds, but so far as the evidence goes, and it is no more than suggestive at best, their evolutionary change, in fundamental features, were always directed towards the final development of a mammalian structure.

I wish to acknowledge my indebtedness to the Percy Sladen Trustees, who assisted me in visiting the South African Museums. To Dr. Smith Woodward I owe the opportunity of describing the material in the British Museum (Natural History), which is the basis of this paper, and I also owe to him and to Dr. C. W. Andrews thanks for their many kindnesses during my work at the Museum. Finally, I have to thank Mr. R. Hall, chief "mason" at the Museum, who developed the skulls described in this paper from a matrix which in many places is as hard as flint.

## EXPLANATION OF THE PLATES.

## PLATE IV.

- Fig. 1. Skull of *Mormosaurus seeleyi*, gen. et sp. n. Type specimen (R. 3594).  
From side. About  $\frac{1}{3}$  nat. size.
- Fig. 2. Skull of *Mormosaurus seeleyi*, gen. et sp. n. Type specimen (R. 3594).  
Obliquely from front. About  $\frac{1}{6}$  nat. size.

## PLATE V.

Skull of *Titanosuchus ferox* Owen. (R. 3595.) From above.  
About  $\frac{1}{3}$  nat. size.









G.M. Woodward del et lith.

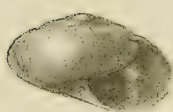
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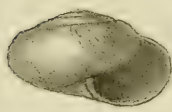
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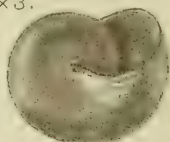
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4x4.



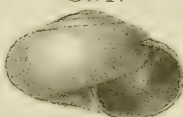
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5x4.



6x4.



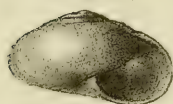
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8x3.



9x2½.



10x4.



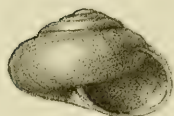
11x2½.



12x2½.



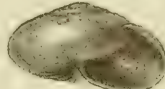
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14x3.



15x3.



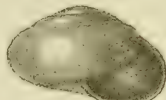
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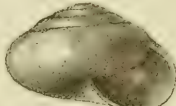
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18x4.



19x4.



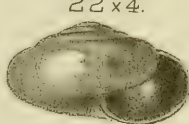
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21x3.



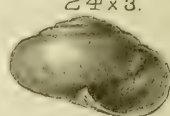
22x4.



23x5.



24x3.



25x2½.



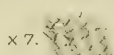
25<sup>a</sup>x2½.



25<sup>b</sup>x2½.



x5.



x7.

27x3.



x7.



x10.



26x3.



28x4.



## 43. Diagnoses of new Genera and Species of Zonitidæ from Equatorial Africa. By H. B. PRESTON, F.Z.S.

[Received April 3, 1914: Read May 5, 1914.]

(Plates I.-III. \*)

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| And 74 sp. n., 1 sub-sp. n., and 2 var. n. |        |      |

In working at the present family the author has found it necessary to refer a number of the species to new genera, having found that the Zonitidæ of the Central African region have been, hitherto, in common with those of many other geographical areas, massed together in a few genera, so that these now contain many widely divergent forms; in very few instances has he found, as might have been reasonably expected, that the South African generic and subgeneric terms are applicable to the Central African types, hence the nine new genera described in the present paper.

Generally speaking, the family, as represented in Central Africa, has not, so far, shown in any marked degree, the peculiar local phases common to both genera and species such as the author found when dealing with the agnathous forms from the same localities, and which were described last year in these 'Proceedings.'

## AFRICARION CONCAVOSPIRA, sp. n. (Pl. II. fig. 20.)

Shell subovate, very thin, almost membranaceous, transparent, polished, straw-colour; whorls 3, the first two small, sunken, sculptured with punctate spiral striæ, the last whorl large, raised above the first two, dilated in front, marked only with transverse growth-plications; suture deeply impressed, bordered below by an ill-defined granular zone; columella margin descending in a rounded curve; labrum simple, projecting in front, receding above and below; aperture broadly dilated.

Alt. 7.25, diam. maj. 12, diam. min. 8.5 mm.

Aperture: alt. 7.25, diam. 7.5 mm.

*Hab.* Kiduha, Lake Mutanda, S.W. Uganda. (Robin Kemp.)

\* For explanation of the Plates see p. 810.

*AFRICARION COPIOSA*, sp. n. (Pl. II. fig. 13.)

Shell subelliptical, solidly corneous, brownish olive; whorls 3, rapidly increasing, the last very large, marked with transverse, radiate growth-plicæ and irregular, distant, scratch-like, spiral sulcations; suture impressed; base of shell moderately convex; columella margin arched above, angled and obliquely descending below; labrum simple, considerably projecting in front, receding above and below; aperture ovate.

Alt. 9·75, diam. maj. 17, diam. min. 12·5 mm.

Aperture: alt. 9, diam. 10·5 mm.

*Hab.* Burunga, Mount Miken, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*AFRICARION KIDUHAËNSIS*, sp. n. (Pl. II. fig. 16.)

Shell differing from *A. copiosa* Preston in its more globular form, membranaceous texture, slightly paler colour, more obliquely descending columella margin and more circular aperture.

Alt. 9, diam. maj. 14·75, diam. min. 11 mm.

Aperture: alt. 8·25, diam. 9 mm.

*Hab.* Kiduha, Lake Mutanda, S.W. Uganda. (Robin Kemp.)

*AFRICARION MARSABITENSIS*, sp. n. (Pl. II. fig. 14.)

Shell ovate, much inflated, thin, pale reddish brown; whorls 3, the last two rapidly increasing, the earlier whorls marked with punctate spiral striæ, the last with arcuate transverse growth-lines only; suture very lightly impressed, narrowly margined below; base of shell inflated; columella margin obliquely descending, broadly curving below; labrum simple, acute; aperture roundly ovate.

Alt. 12·75, diam. maj. 15·75, diam. min. 12 mm.

Aperture: alt. 10·75, diam. 9·5 mm.

*Hab.* Northern slopes of Mount Marsabit, British East Africa, at an altitude of 4600 feet. (A. Blayney Percival.)

*AFRICARION ORESTIAS*, sp. n. (Pl. II. fig. 15.)

Shell rather small, ovate, very thin, almost membranaceous, pale yellowish brown, polished, shining; whorls 3, rapidly increasing, the last very large, moderately convex, projecting in front; suture almost linear, narrowly margined below; columella margin descending in a rounded curve; aperture wide, very large, dilated, roundly ovate; labrum membranaceous, receding above and below.

Alt. 6, diam. maj. 9·5, diam. min. 7·25 (nearly) mm.

Aperture: alt. 5·5, diam. 5·75 mm.

*Hab.* Slopes of Mount Kenia, British East Africa. (Robin Kemp.)

*AFRICARION OSCITANS*, sp. n. (Pl. II. fig. 4.)

Shell thin, pale amber-colour, semioval, depressed, the spire very slightly exerted; whorls 3, rapidly increasing, the first two

sculptured with spiral punctate lines, the last obsoletely, obliquely, arcuately, transversely plicate; suture impressed, margined above, the margin being of a pinkish colour; columella margin almost vertically descending above, gently curved below; labrum simple, projecting in front, receding considerably below and a little above; aperture large, wide, subovate.

Alt. 9·5, diam. maj. 13·5, diam. min. 9·75 mm.

Aperture: alt. 7, diam. 8 mm.

*Hab.* Lake Mutanda, S.W. Uganda. (Robin Kemp.)

*AFRICARION SPATIOSA*, sp. n. (Pl. II. fig. 17.)

Shell oblong, depressed, thin, nearly membranaceous, straw-coloured, polished, shining; whorls 3, the first two very small and sculptured with somewhat distant, punctate, spiral striæ, the last very large, and marked only with radiate, wrinkle-like plications; suture lightly impressed, callously margined below; base of shell inflated; columella excavated; aperture ovate, very wide, and broad.

Alt. 7·5, diam. maj. 11·75, diam. min. 8 mm.

Aperture: alt. 7·25, diam. 9·25 mm.

*Hab.* Burunga, Mount Mikeno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*AFRICARION KAGAMBAHENSIS*, sp. n. (Pl. II. fig. 18.)

Shell differing from *A. spatiosa* Preston in its more ovate form, in the greater elevation of the spire, in its broader and much more convex base, and in the shape of the aperture, which is much narrower and higher in proportion to its breadth; moreover, the punctate spirals on the earlier whorls are much finer and more closely set than is the case with *A. spatiosa*.

Alt. 8 (nearly), diam. maj. 11, diam. min. 8 mm.

Aperture: alt. 7·75, diam. 8·25 mm.

*Hab.* Kagambah, S.W. Uganda. (Robin Kemp.)

*AFRICARION TENEBROSA*, sp. n. (Pl. II. fig. 19.)

Shell subelliptical, thin, almost membranaceous, dark reddish brown, polished, shining; whorls 3, rapidly increasing, the last large, sculptured with transverse growth-lines; suture impressed, margined below, the margin being of a darker colour than the remainder of the shell; columella margin descending obliquely, obtusely angled and excavated below; labrum simple, projecting in front, receding above and below; aperture ovate.

Alt. 7, diam. maj. 10·25, diam. min. 9·5 mm.

Aperture: alt. 6, diam. 8 mm.

*Hab.* Burunga, Mount Mikeno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*GUDEËLLA ARANEA*, sp. n. (Pl. III. fig. 20.)

Shell somewhat depressedly turbinate, yellowish brown; whorls 5, regularly increasing, the last subangular just above the

periphery; sculptured with extremely fine, closely-set, wavy, microscopic, spiral striæ, which appear to be rather coarser in the subsutural region; suture impressed, narrowly margined below; perforation narrow, internally slightly angled and sculptured with somewhat distant and coarse, spiral liræ crossed by radiate growth-puckerings; columella descending in a curve, very slightly outwardly reflexed above; labrum simple; aperture obliquely and compressedly sublunate.

Alt. 3.25, diam. maj. 6, diam. min. 5.25 mm.

Aperture: alt. 2, diam. 2.5 mm.

*Hab.* Between Entebbe and Masaka, S.W. Uganda. (Robin Kemp.)

The internal sculpture of the umbilicus somewhat resembles the pattern of a spider's web, hence the trivial name.

*GUDEËLLA BARTAËNSIS*, sp. n. (Pl. III. fig. 6.)

Shell very depressedly turbinate, pale brownish yellow; whorls  $4\frac{1}{2}$ , regularly increasing, sculptured throughout with very fine, closely-set, wavy, spiral striæ; suture impressed, very narrowly margined; umbilicus narrow, deep; columella outwardly reflexed above, very slightly obliquely descending; labrum simple; aperture sublunate.

Alt. 3.5 (nearly), diam. maj. 6.25, diam. min. 5.25 mm.

Aperture: alt. 3, diam. 2.75 mm.

*Hab.* Barta Steppes, British East Africa. (A. Blayney Percival.)

*GUDEËLLA KAMPALAËNSIS*, sp. n. (Pl. III. fig. 10.)

Shell differing from *G. bartaënsis* Preston in its smaller size, much more narrowly margined suture, and in being microscopically spirally striate throughout; the aperture is also more obliquely and compressedly sublunate.

Alt. 3, diam. maj. 5.25, diam. min. 5 (nearly) mm.

Aperture: alt. 2.25, diam. 2.25 mm.

*Hab.* Kampala on Lake Victoria Nyanza, S.W. Uganda; also found at Entebbe and Jinja in the same district. (Robin Kemp.)

*GUDEËLLA URGUESSENSIS*, sp. n. (Pl. III. fig. 17.)

Shell closely allied to *G. bartaënsis* Preston, but rather broader, with wider umbilicus and much more oblique columella; the aperture is considerably broader, though no higher, and the microscopic spiral sculpture is much finer than is the case in that species.

Alt. 3.75, diam. maj. 6.75, diam. min. 6 mm.

Aperture: alt. 2.25, diam. 2.75 mm.

*Hab.* Urguess, British East Africa. (A. Blayney Percival.)

*GUDEËLLA CONSUETA*, sp. n. (Pl. III. fig. 18.)

Shell thin, depressedly turbinate, polished, shining, pale reddish brown; whorls  $4\frac{1}{2}$ , regularly increasing, the last subangulate at

the periphery, sculptured throughout with very fine, wavy, spiral striæ; suture impressed, margined below; umbilicus narrow, deep; columella margin obliquely descending, extending above into a thin, parietal callus; labrum acute; aperture rather obliquely sublunate.

Alt. 3, diam. maj. 6, diam. min. 5.25 mm.

Aperture: alt. 2.5, diam. 2.5 mm.

*Hab.* Between Mbarara and Masaka, S.W. Uganda. (Robin Kemp.)

*GUDEËLLA USITATA*, sp. n. (Pl. III. fig. 2.)

Shell differing from *G. consueta* Preston in its smaller size and comparatively rather more elevated spire, in having half a whorl less, and in its more vertical columella and proportionately broader aperture; the spiral sculpture is also much finer on the whorls than on the base of the shell, while in *G. consueta* it is regular throughout.

Alt. 2.75, diam. maj. 4.5, diam. min. 4 mm.

Aperture: alt. 2, diam. 2.5 mm.

*Hab.* Between Masaka and Entebbe, S.W. Uganda. (Robin Kemp.)

*GUDEËLLA DENSESCULPTA*, sp. n. (Pl. III. fig. 14.)

Shell very depressedly turbinate, thin, subhyaline, pale greyish straw-colour; whorls 5, regularly increasing, very closely, microscopically, spirally striate; suture impressed, callously margined below, the marginal callus being rather more coarsely and distantly, spirally striate than the remainder of the shell; umbilicus narrow; columella descending in a very oblique curve; labrum simple; aperture rather obliquely sublunate.

Alt. 3.5, diam. maj. 7, diam. min. 6 mm.

Aperture: alt. 3, diam. 2.75 mm.

*Hab.* Kagambah, S.W. Uganda. (Robin Kemp.)

*GUDEËLLA MIME*, sp. n. (Pl. III. fig. 23.)

Shell differing from *G. densesculpta* Preston in its much smaller size, in having one whorl less, and in its darker colour, which is of an amber hue; the last whorl is subangulate above, the columella margin descends vertically and the aperture, though sublunate, is less oblique.

Alt. 2, diam. maj. 3.75, diam. min. 3.25 mm.

Aperture: alt. 1.75, diam. 1.75 mm.

*Hab.* Kagambah, S.W. Uganda. (Robin Kemp.)

*GUDEËLLA ELGONENSIS*, sp. n. (Pl. III. fig. 19.)

Shell turbinate, not very depressed, polished, shining, pale brownish horn-colour; whorls 5, regularly increasing, the last rounded, the remainder flattish, sculptured with very fine and closely-set, microscopic, wavy, spiral striæ, the same sculpture also occurring on the base of the shell; suture impressed, very

narrowly margined below; umbilicus narrow, partly overhung by the outward expansion of the upper portion of the columella; columella margin outwardly expanded and slightly curved above, not outwardly expanded and very obliquely descending below; labrum simple; aperture broadly, obliquely subulate.

Alt. 3.75, diam. maj. 6.5, diam. min. 6 mm.

Aperture: alt. 2.75, diam. 3 (nearly) mm.

*Hab.* Mount Elgon, Uganda. (C. W. Woodhouse.)

*GUDEELLA GERSTENBRANDTI*, sp. n. (Pl. III. fig. 7.)

Shell differing from *G. elgonensis* Preston in its smaller size and more compressed last whorl, darker colour, and more curved columella; the aperture also is proportionately not so broad and is less oblique.

Alt. 3.5 (nearly), diam. maj. 5.75, diam. min. 5 mm.

Aperture: alt. 2.5, diam. 2.5 mm.

*Hab.* Mount Elgon, Uganda. (C. W. Woodhouse.)

*GUDEELLA WOODHOUSEI*, sp. n. (Pl. III. fig. 13.)

Shell allied to *G. elgonensis* Preston, but larger, with more obtuse apex and more convex whorls, the columella is much more vertically descending and the aperture is proportionately higher than in that species.

Alt. 5, diam. maj. 7.25, diam. min. 6.5 mm.

Aperture: alt. 3, diam. 3 mm.

*Hab.* Mount Elgon, Uganda. (C. W. Woodhouse.)

*GUDEELLA INCLINANS*, sp. n. (Pl. III. figs. 1 & 8.)

Shell depressed with sloping sides, thin, reddish brown becoming paler on the base towards the umbilical area; whorls 4, rather rapidly increasing, having a somewhat drooping appearance, the last very slightly descending in front, marked with radiate growth-plicæ which are more noticeable in the subsutural region and sculptured throughout with fine, wavy, spiral striæ; suture impressed, margined below; umbilicus narrow, partly concealed by the outward expansion of the columella; columella margin outwardly expanded and descending in a gentle curve above, oblique below; labrum simple, acute, projecting in front, slightly receding above, greatly receding below; aperture broadly and somewhat obliquely subulate.

Alt. 3.75 (nearly), diam. maj. 7, diam. min. 6 mm.

Aperture: alt. 3.25, diam. 3 mm.

*Hab.* Burunga, Mount Mikeno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*GUDEELLA INFLATA*, sp. n. (Pl. III. fig. 21.)

Shell differing from *G. inclinans* Preston in its larger size, much more inflated form, and darker colour which is uniform throughout, much finer spiral sculpture and more narrow umbilicus, more vertically descending columella and ovate aperture.

Alt. 5·25, diam. maj. 7·75, diam. min. 6·5 mm.

Aperture : alt. 4·25, diam. 3·75 mm.

*Hab.* Burunga, Mount Mikenö, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*GUDEELLA IRIDESCENS*, sp. n. (Pl. III. fig. 15.)

Shell allied to *G. inclinans* Preston, but rather larger, though having the same number of whorls and with coarser spiral sculpture, the sutural margin is broader and the columella descends vertically above, and is then angled and very oblique below, the aperture consequently being broader than in *G. inclinans*; when placed under the microscope the surface of the shell appears to be highly iridescent.

Alt. 4·25, diam. maj. 7·75, diam. min. 6·25 mm.

Aperture : alt. 3·25, diam. 3·5 mm.

*Hab.* Mount Mikenö, Belgian Congo. (Robin Kemp.)

*GUDEELLA MARSABITENSIS*, sp. n. (Pl. III. fig. 22.)

Shell somewhat depressedly orbicular, thin, semi-transparent, pale reddish brown; whorls 5, regularly increasing, the last subangulate above, sculptured with very fine, wavy, closely-set, spiral striæ; suture impressed, margined below, the margin rather more coarsely spirally striate than the remainder of the surface and having the spiral striæ crossed by very oblique, scratch-like lines; base of shell moderately convex, sculptured with exceedingly fine, microscopic, wavy, spiral striæ and coarser, somewhat distant, revolving lines; umbilicus rather wide, deep; columella margin outwardly expanded above, curved, obliquely descending below; labrum simple; aperture obliquely sublunate.

Alt. 3·5, diam. maj. 6·75, diam. min. 6 mm.

Aperture : alt. 2·75, diam. 3 mm.

*Hab.* Northern slopes of Mount Marsabit, British East Africa, at an altitude of 4600 feet. (A. Blayney Percival.)

*GUDEELLA MASAKAËNSIS*, sp. n. (Pl. III. fig. 16.)

Shell very depressedly turbate, olivaceous brown, polished, shining; whorls 4, regularly increasing, sculptured with very fine, wavy, closely-set, microscopic, spiral striæ; suture impressed, margined below, the sculpture on the margins, as also on the base of the shell, being slightly coarser than on the remainder of the upper surface; umbilicus narrow, not deep; columella margin outwardly reflexed above, descending in a very oblique curve, extending into a very thin, but well-defined, parietal callus which enters the mouth of the shell just behind the upper margin of the labrum; labrum simple, receding below; aperture obliquely, broadly, and rather compressedly sublunate.

Alt. 2·5, diam. maj. 5, diam. min. 4·25 mm.

Aperture : alt. 1·75, diam. 2 mm.

*Hab.* Between Entebbe and Masaka, S.W. Uganda. (Robin Kemp.)

*GUDEËLLA MULTISTRIATA*, sp. n. (Pl. III. fig. 3.)

Shell small, thin, depressed, suborbicular, pale yellowish horn-colour; whorls 4, sculptured throughout with fine, very closely-set, spiral striae, the last large; suture lightly impressed, margined below; perforation nearly concealed by the rather broad outward expansion of the columella margin; columella margin obliquely descending; labrum simple, acute; aperture broadly obliquely sublunate.

Alt. 2.75, diam. maj. 5.75, diam. min. 5 mm.

Aperture: alt. 2.5, diam. 2.75 mm.

*Hab.* Buhamba, near Lake Kivu, Belgian Congo. (Robin Kemp.)

Allied to *Thapsia insimulans* Smith\* from the Nyika Plateau, British Central Africa, but larger, with broader whorls and coarser spiral sculpture.

*GUDEËLLA MUKANDAËNSIS*, sp. n. (Pl. III. fig. 11.)

Shell differing from *G. kigeziensis* Preston† in its larger size, much paler colour, more exserted spire, narrower umbilicus, more oblique aperture, and in being microscopically spirally sculptured above, which is not the case with *G. kigeziensis*.

Alt. 4.5, diam. maj. 9.25, diam. min. 8 mm.

Aperture: alt. 4, diam. 3.75 mm.

*Hab.* Mukanda, near Lake Kivu. (Robin Kemp.)

*GUDEËLLA MUKANDAËNSIS*, var. *MUTANDANA*, var. n. (Pl. III. fig. 12.)

Shell differing from the typical form in being rather more widely perforate, darker in colour, with oblique columella margin and more rounded aperture.

Alt. 4.75, diam. maj. 9.5 (nearly), diam. min. 7.75 mm.

Aperture: alt. 4.25, diam. 4.25 mm.

*Hab.* Lake Mutanda, S.W. Uganda. (Robin Kemp.)

*GUDEËLLA CONSOBRINA*, sp. n. (Pl. III. fig. 9.)

Shell differing from *G. mukandaënsis* Preston in its colour, which is of a creamy hue, much more inflated form, more vertically descending columella margin, less oblique, wider, and more compressed aperture, and in the total absence of spiral sculpture.

Alt. 5, diam. maj. 9.25, diam. min. 8 (nearly) mm.

Aperture: alt. 4.25, diam. 4.25 mm.

*Hab.* Mukanda, near Lake Kivu. (Robin Kemp.)

*GUDEËLLA NEMORUM*, sp. n. (Pl. III. fig. 24.)

Shell perforate, depressedly turbinate, thin, somewhat polished, very light reddish brown; whorls 5, regularly increasing, not convex, the last slightly shouldered above, sculptured with very

fine, closely-set, wavy, spiral striæ; suture impressed, margined below; base of shell sculptured as above; umbilicus rather wide, deep; columella margin outwardly expanded, descending in a very oblique curve, diffused above into a thin, well-defined, outwardly projecting, parietal callus which reaches the upper margin of the labrum; labrum acute, slightly sinuous, projecting in front, receding below and slightly above; aperture rather broadly obliquely sublunate.

Alt. 3·75, diam. maj. 7, diam. min. 6 mm.

Aperture: alt. 3, diam. 3·25 mm.

*Hab.* Forests to the north of Mount Kenia, British East Africa. (A. Blayney Percival.)

*GUDEELLA PALLIDIOR*, sp. n. (Pl. III. fig. 5.)

Shell depressedly orbicular, greyish yellow, polished, shining; whorls 4, regularly increasing, sculptured with microscopic, closely-set, spiral striæ; base of shell sculptured with fine, slightly distant and wavy, revolving, scratch-like striæ; suture impressed, margined below; umbilicus narrow, very slightly overhung by the outward expansion of the columella; columella margin descending in an oblique curve; labrum simple, whitish at the extreme edge; aperture rather broadly, obliquely, and compressedly sublunate.

Alt. 3, diam. maj. 5·75, diam. min. 5 mm.

Aperture: alt. 2·5, diam. 2·75 (nearly) mm.

*Hab.* Urguess, British East Africa. (A. Blayney Percival.)

*GUDEELLA TRIBULATIONIS*, sp. n. (Pl. III. fig. 4.)

Shell depressedly turbinate, shining, pale reddish brown; whorls 4, sculptured throughout with fine, closely-set, wavy, spiral striæ; base of shell pale yellowish grey; suture impressed, narrowly margined below, the margin being of a whitish colour; umbilicus deep, but very narrow; columella vertically descending above, slightly oblique, and curved below; labrum simple; aperture compressedly sublunate.

Alt. 3·5, diam. maj. 5·75, diam. min. 5 mm.

Aperture: alt. 2·5, diam. 2·75 (nearly) mm.

*Hab.* Mount Elgon, S.W. Uganda. (C. W. Woodhouse.)

#### *ELGONELLA*, gen. nov.

Shell rather small, corneous, perforate, turbinate or depressedly so, marked only with transverse plications or growth-striæ, and having the labrum slightly reflexed.

Genotype: *E. eulotæformis* Preston.

The genus should also include:—

*Zingis gaziensis* Preston, from Gazi, British East Africa, Ann. Mag. Nat. Hist. London, ser. 8, vol. vii. 1911, p. 467, pl. xi. fig. 10.

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*Zingis consanguinea* Preston, from the Mount Kenia Region, t. c. fig. 11.

*Zingis kemp*i Preston, from S.W. Uganda, Proc. Zool. Soc. London, 1912, p. 185, pl. xxxii. fig. 14.

*ELGONELLA EULOTÆFORMIS*, sp. n. (Pl. II. figs. 9 a, 9 b, 9 c.)

Shell perforate, moderately solid, turbinate, pale yellowish, slightly polished; whorls 5, regularly increasing, sculptured with very oblique, transverse growth plications and striæ; suture impressed; umbilicus somewhat wide, deep; columella outwardly reflexed above, descending in a rather oblique curve; labrum acute, narrowly reflexed; aperture compressedly and very broadly sublunate.

Alt. 5·5, diam. maj. 7·25, diam. min. 6·5 mm.

Aperture: alt. 4·25, diam. 3·25 mm.

*Hab.* Kagambah, S.W. Uganda. (Robin Kemp.)

*ELGONELLA BRUNNEA*, sp. n. (Pl. II. figs. 11 a, 11 b.)

Shell perforate, turbinate, dark grey, covered with a thin, dark brown periostracum; whorls 5, the last somewhat convex, marked with oblique, rather coarse growth-ridges; suture impressed, crenellated by the terminations of the transverse growth-ridges; umbilicus rather wide, deep; columella descending obliquely, curved above and slightly outwardly expanded; labrum simple; aperture broadly sublunate.

Alt. 4·75 (nearly), diam. maj. 7 (nearly), diam. min. 6 mm.

Aperture: alt. 3, diam. 2·5 (nearly) mm.

*Hab.* Rumruti, British East Africa. (Robin Kemp.)

*ELGONELLA DISCOLORATA*, sp. n. (Pl. II. figs. 7 a, 7 b.)

Shell depressedly turbinate, greyish, mottled, clouded and closely spirally striated or banded with cream-colour; whorls 5, regularly increasing, smooth but for growth-markings; suture impressed; umbilicus moderately wide, deep; columella vertically descending above, curved below, slightly reflexed; labrum simple; aperture somewhat oblique, ovate.

Alt. 4·5, diam. maj. 8, diam. min. 7 mm.

Aperture: alt. 3·25, diam. 3 mm.

*Hab.* Larogi Hills, British East Africa. (A. Blayney Percival.)

The cream-coloured markings seem to be caused by local opaqueness in the texture of the shell.

*ELGONELLA FLAVIDULA*, sp. n. (Pl. II. figs. 5 a, 5 b.)

Shell perforate, depressedly turbinate, rather thin, pale yellowish; whorls 5, marked only with irregular, oblique, arcuate growth-lines; suture impressed; umbilicus rather broad, open deep; columella margin outwardly expanded above, descending in a curve; labrum simple; aperture compressedly ovate.

Alt. 5, diam. maj. 8·25, diam. min. 7·25 mm.

Aperture: alt. 3·25, diam. 2·75 mm.

*Hab.* Mount Elgon, Uganda. (C. W. Woodhouse.)

*ELGONELLA ANGUSTIOR*, sp. n. (Pl. II. figs. 6 *a*, 6 *b*.)

Shell allied to *E. flavidula* Preston, but of a pale brown colour and more narrowly turbinate, with subangulate last whorl; the umbilicus is narrower, the aperture is higher and narrower, and the margins of the labrum are convergent.

Alt. 4.5, diam. maj. 7.25, diam. min. 7 mm.

Aperture: alt. 3, diam. 3 mm.

*Hab.* Mount Elgon, S.W. Uganda. (C. W. Woodhouse.)

*ELGONELLA ORIBATES*, sp. n. (Pl. II. figs 8 *a*, 8 *b*.)

Shell small, turbinate, light reddish brown, smooth, slightly polished; whorls  $4\frac{1}{2}$ , regularly increasing, marked with oblique growth-lines; suture impressed; umbilicus very narrow, deep; columella rather broadly outwardly expanded, descending in a rather gentle curve; labrum simple; aperture roundly ovate.

Alt. 4.25, diam. maj. 5.75, diam. min. 5 mm.

Aperture: alt. 3, diam. 3 mm.

*Hab.* Mount Elgon, Uganda. (C. W. Woodhouse.)

*ELGONELLA ROBINI*, sp. n. (Pl. II. figs. 10 *a*, 10 *b*.)

Shell perforate, turbinate, light brown, smooth, but for oblique growth-ridges; whorls  $4\frac{1}{2}$ , regularly increasing, the last subangulate at the periphery; suture impressed; umbilicus moderately narrow, deep; columella slightly excavated above, somewhat vertically descending below; labrum simple; aperture very compressedly, broadly sublunate.

Alt. 4, diam. maj. 6.25, diam. min. 5.75 mm.

Aperture; alt. 2.75, diam. 2.5 mm.

*Hab.* Rumruti, British East Africa. (Robin Kemp.)

*ELGONELLA SOBRINA*, sp. n. (Pl. II. figs. 12 *a*, 12 *b*.)

Shell differing from *E. robini* Preston in its smaller and proportionately much more depressed form and in its rounded last whorl; it has half a whorl less and the growth-ridges are much more marked and the umbilicus is narrower; the columella and the aperture are somewhat more oblique and the latter is proportionately broader.

Alt. 3.5, diam. maj. 5.75, diam. min. 5 mm.

Aperture: alt. 2.25, diam. 2.5 mm.

*Hab.* Rumruti, British East Africa. (Robin Kemp.)

*BURUNGAËLLA*, gen. nov.

Shell thin, corneous, whorls rather tightly coiled, the last *proportionately large*, more or less obsoletely, transversely plicate; aperture somewhat large.

Genotype: *B. oscitans* Preston.

*BURUNGAËLLA OSCITANS*, sp. n. (Pl. I. figs. 17 *a*, 17 *b*, 17 *c*.)

Shell perforate, very thin, almost membranaceous, very depressedly turbinate above, convex below, pale brownish straw-

colour; whorls 5, regularly increasing, the last large, marked with obsolete, oblique, transverse, crease-like plications which are more developed in the subsutural region; suture impressed; base of shell somewhat inflated; umbilicus rather narrow, deep, partly overhung by the outward expansion of the columella; columella very slightly curved, scarcely oblique; labrum simple, membranaceous, projecting a little in front; aperture ovate.

Alt. 7.5, diam. maj. 10.75, diam. min. 8.25 mm.

Aperture: alt. 6.25, diam. 4.5 mm.

*Hab.* Burunga, Mount Mikeno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*BURUNGAËLLA BUHAMBAËNSIS*, sp. n. (Pl. I. fig. 16.)

Shell perforate, thin, corneous, turbinate, pale yellowish brown; whorls 5, the first small, the second somewhat large in proportion, the remainder regularly increasing, slightly convex, irregularly and obsoletely plicate and sculptured with wavy, transverse striae, the last whorl angled at the periphery; suture impressed, very narrowly margined below; umbilicus very narrow, deep, almost covered by the upper, broad, outward expansion of the columella margin; columella margin membranaceous, broadly, triangularly, outwardly expanded and nearly vertically descending above, then angled and very obliquely descending below; aperture broadly and rather compressedly obliquely subrescentic.

Alt. 5.5, diam. maj. 7, diam. min. 6 mm.

Aperture: alt. 4, diam. 3 mm.

*Hab.* Buhamba, near Lake Kivu, Belgian Congo. (Robin Kemp.)

*BURUNGAËLLA IMPERFORATA*, sp. n. (Pl. I. fig. 15.)

Shell imperforate, turbinate, very thin, yellowish brown; whorls 5, regularly increasing, the last somewhat inflated, the last two microscopically spirally striate and marked with oblique, transverse, crease-like plicae; suture impressed; base of shell inflated; columella obliquely descending, outwardly, callously expanded above; aperture depressedly and very broadly subnulate.

Alt. 6.25, diam. maj. 9.25, diam. min. 7.75 mm.

Aperture: alt. 4.75, diam. 4.25 mm.

*Hab.* Burunga, Mount Mikeno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*BURUNGAËLLA MUTANDANA*, sp. n. (Pl. I. fig. 14.)

Shell rather depressedly turbinate, thin, pale yellowish brown; whorls  $4\frac{1}{2}$ , regularly increasing, the last subangulate at the periphery, marked with oblique transverse riblets or creases, which become obsolete on the base; suture impressed, crenellated by the terminations of the transverse riblets; umbilicus moderately narrow, deep; columella rather broadly outwardly expanded

above, descending in a somewhat oblique curve; labrum thin, almost membranaceous, very slightly reflexed; aperture ovate.

Alt. 5, diam. maj. 8·75, diam. min. 7·25 mm.

Aperture; alt. 4, diam. 4·25 (nearly) mm.

*Hab.* Lake Mutanda, extreme S.W. Uganda. (Robin Kemp.)

BLAYNEYELLA, gen. nov.

Shell thin, corneous, narrowly umbilicate, depressedly turbate, transversely plicate; *labrum a little reflexed.*

Genotype: *B. percivali* Preston.

Generally, but not always, ornamented with a peripheral purplish band.

*Zingis papyracea* Preston, from S.W. Uganda, Proc. Zool. Soc. London, 1912, p. 185, pl. xxxii. fig. 15, may also be considered as belonging to *Blayneella*.

BLAYNEYELLA PERCIVALI, sp. n. (Pl. I. figs. 19 a, 19 b, 19 c.)

Shell perforate, turbate, thin, pale yellowish brown, painted with a rather narrow, supersutural, reddish-purple band, which appears on the last whorl as a superperipheral band; whorls 5, the last gradually descending in front, marked with oblique, arcuate, irregular, crease-like riblets; suture impressed, faintly margined below; umbilicus moderately narrow, very deep, slightly overhung by the outward reflexion of the columella; columella curved, diaphanous, rather broadly outwardly reflexed above, narrowly so below; labrum simple; aperture ovate; interior of shell showing the superperipheral band through the test.

Alt. 9·5, diam. maj. 14·25, diam. min. 11·75 mm.

Aperture: alt. 7·25, diam. 6·75 mm.

*Hab.* Larogi Hills, British East Africa. (A. Blayne Percival.)

BLAYNEYELLA KISENGIENSIS, sp. n. (Pl. I. fig. 21.)

Shell perforate, depressedly turbate, thin, very pale reddish brown; whorls  $5\frac{1}{2}$ , regularly, but rather rapidly, increasing, marked with somewhat indistinct, oblique, radiate riblets; suture impressed; base of shell rather convex; umbilicus moderately wide, deep; columella outwardly expanded above, descending in a curve; aperture broadly sublunate.

Alt. 8·25, diam. maj. 13·25, diam. min. 11 mm.

Aperture: alt. 5·25, diam. 5·75 mm.

*Hab.* Kisengi, Lake Kivu, German East Africa, at an altitude of 4500 feet. (Robin Kemp.)

BLAYNEYELLA PURPUREOCINCTA, sp. n. (Pl. I. fig. 20.)

Shell perforate, thin, corneous, depressedly turbate, yellowish brown, painted with a narrow, supersutural, reddish-purple band, which appears on the last whorl as a superperipheral band; whorls 6, regularly increasing, marked with oblique transverse

growth-striae; suture impressed; base of shell somewhat inflated; umbilicus moderately wide and deep; columella rather outwardly expanded, descending in a curve, oblique below; labrum thin, slightly reflexed; aperture very broadly sublunate.

Alt. 6·5, diam. maj. 11·25, diam. min. 9·25 mm.

Aperture: alt. 5·5, diam. 5 mm.

*Hab.* Nairobi, British East Africa. (A. Blayney Percival.)

*BLAYNEYELLA MICROSPIRALIS*, sp. n. (Pl. I. fig. 18.)

Shell allied to *B. purpureocincta* Preston, but differing from that species in its much more depressed form, more obliquely descending columella, and narrower and more compressed aperture, and finely spirally sculptured first whorl, which sculpture is only visible by the aid of the microscope.

Alt. 6, diam. maj. 10·25, diam. min. 8·5 mm.

Aperture: alt. 4·5, diam. 4·5 mm.

*Hab.* British East Africa.

#### *LAROGIELLA*, gen. nov.

Shell umbilicate, thin, corneous, turbinate, transversely plicate: *labrum membranaceous*.

Genotype: *L. venatoris* Preston.

To the above genus should also be assigned:—

*Natalina permembranacea* Preston, from S.W. Uganda, Proc. Zool. Soc. London, 1912, p. 183, pl. xxxi. figs. 20, 20 *a*, & 20 *b*.

*Zingis planispira* Preston, also from S.W. Uganda, *t. c.* p. 185, pl. xxxii. fig. 16.

*LAROGIELLA VENATORIS*, sp. n. (Pl. I. figs. 22, 22 *b*, 22 *c*.)

Shell somewhat depressedly turbinate, thin, yellowish brown; whorls  $5\frac{3}{4}$ , regularly increasing, the last angled at the periphery and descending in front, marked with oblique growth-plicae; suture impressed, almost imperceptibly margined below; umbilicus moderately wide, deep, slightly overhung by the triangular, outward expansion of the columella margin; columella margin descending in a curve; labrum membranaceous; aperture compressedly ovate.

Alt. 7·5, diam. maj. 12·5, diam. min. 10·25 mm.

Aperture: alt. 5, diam. 5·5 mm.

*Hab.* Larogi Hills, British East Africa, at an altitude of from 6000 to 7000 feet. (A. Blayney Percival.)

*LAROGIELLA ANGULIFERA*, sp. n. (Pl. II. fig. 1.)

Shell perforate, depressedly conic, thin, pale brown, painted with an indistinct, whitish, infrasutural band; whorls 5, the last descending in front, regularly increasing and angled at the periphery, marked with irregular, oblique, arcuate, transverse, crease-like riblets and showing traces of spiral whitish lines,

especially in the subsutural region, which latter appear to be in the texture of the shell and not at all in the nature of outward sculpture; suture impressed; base of shell slightly convex, rather more noticeably marked with the whitish textural lines than the rest of the shell; umbilicus moderately wide, deep; columella diffused upwards into a very thin, well-defined, and sinuous parietal callus, which reaches the upper margin of the labrum, curved and outwardly reflexed above, oblique and scarcely reflexed below; labrum simple; aperture oblique, compressedly subovate.

Alt. 8·75, diam. maj. 13·75, diam. min. 11·25 mm.

Aperture: alt. 5·5, diam. 5·75 mm.

*Hab.* Larogi Hills, British East Africa. (A. Blayney Percival.)

*LAROGIELLA FONTICULA*, sp. n. (Pl. II. fig. 3.)

Shell perforate, thin, roundly turbinate, fulvous; whorls 5, regularly increasing, sculptured with irregular, very oblique, radiate, transverse plications and microscopically shagreened; suture impressed; umbilicus narrow, deep, well-like, a little overhung by the outward expansion of the columella margin; columella margin vitreous, broadly outwardly expanded above, descending in a curve; labrum simple; aperture roundly ovate.

Alt. 6·75, diam. maj. 10, diam. min. 8 mm.

Aperture: alt. 5, diam. 4·5 mm.

*Hab.* Lake Mutanda, S.W. Uganda. (Robin Kemp.)

*LAROGIELLA KOMBAËNSIS*, sp. n. (Pl. II. fig. 2.)

Shell perforate, thin, submembranaceous, pale yellowish brown; whorls 4, regularly increasing, sculptured throughout with regular, oblique, somewhat arcuate, transverse, crease-like plicæ; suture impressed; base of shell moderately inflated; umbilicus rather wide, deep; columella vitreous, widely outwardly reflexed above, descending in a very slightly oblique curve; labrum thin, acute, projecting a little in front; aperture ovate.

Alt. 4·75, diam. maj. 10, diam. min. 8 mm.

Aperture: alt. 5·25, diam. 4 mm.

*Hab.* Komba, S.W. Uganda. (Robin Kemp.)

*LAROGIELLA MALASANJENSIS*, sp. n. (Pl. I. fig. 23.)

Shell somewhat depressedly turbinate, thin, pale brown; whorls 5, regularly increasing, the last subangulate at the periphery, marked with oblique, arcuate, transverse plications; suture impressed; base of shell marked with very fine, wavy, revolving striæ in addition to the transverse sculpture; umbilicus moderately wide, deep; columella descending in an oblique curve, outwardly expanded above; labrum thin, membranaceous; aperture broadly and compressedly sublunate.

Alt. 5·25, diam. maj. 9·5, diam. min. 8·25 mm.

Aperture: alt. 4·5, diam. 3·25 mm.

*Hab.* Malasanji, S.W. Uganda. (Robin Kemp.)

## NAKURUËLLA, gen. nov.

Shell umbilicate, turbinate, thin, corneous, transversely plicate, with *broad aperture*.

Genotype: *Zingis bullata* Preston\*.

NAKURUËLLA SOROR, sp. n. (Pl. I. figs. 13 *a*, 13 *b*, 13 *c*.)

Shell differing from *N. bullata* Preston in its more depressed form, in having a whorl less, in its still narrower umbilicus, and rather more oblique and much broader aperture; the basal portion of the labrum is also slightly reflexed.

Alt. 11, diam. maj. 17, diam. min. 13 mm.

Aperture: alt. 8·5, diam. 8·75 mm.

*Hab.* Burunga, Mount Mikenno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

## MIKENOËLLA, gen. nov.

Shell thin, corneous, narrowly perforate, with *somewhat elevated spire*, transversely plicate only, labrum acute.

Genotype: *M. ahena* Preston.

Species which should probably be referred to this genus are:—

*Zingis gregorii* Smith, from Mt. Kenia, Proc. Malac. Soc. Lond. vol. i. p. 164.

*Zingis aurea* Preston, from British East Africa, Rev. Zool. Africaine, Bruxelles, vol. iii. p. 47, pl. v. fig. 6.

MIKENOËLLA AHENA, sp. n. (Pl. II. figs. 26 *a*, 26 *b*, 26 *c*.)

Shell perforate, conically turbinate, very thin, pale yellowish brown; whorls 5, regularly increasing, the last large, obsoletely transversely plicate, the plicæ being more noticeable in the sub-sutural region; suture impressed, very narrowly margined below; base of shell inflated; umbilicus narrow, deep, partly concealed by the outward reflexion of the columella margin; columella margin broadly and membranaceously outwardly reflexed above, almost vertically descending in a gentle curve; labrum acute; aperture ovate.

Alt. 11·25, diam. maj. 13, diam. min. 11 mm.

Aperture: alt. 7·25, diam. 5 mm.

*Hab.* Burunga, Mount Mikenno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

MIKENOËLLA ELEVATA, sp. n. (Pl. II. fig. 25.)

Shell perforate, inflatedly turbinate, thin, yellowish brown, painted just above the suture and periphery with a broad spiral band of purplish red, below which occurs a peripheral narrow band of a creamy colour; whorls  $5\frac{1}{2}$ , regularly increasing, the last inflated, marked only, especially on the upper whorls, with fine oblique growth-plicæ; suture impressed; base of shell inflated,

\* Rev. Zool. Africaine, Bruxelles, vol. iii. pp. 47-48, pl. v. fig. 4.

marked with radiate arcuate growth-plications and discoloured with a purplish tinge in the circum-umbilical region; perforation narrow, deep, slightly overhung by the outward expansion of the columella; columella triangularly outwardly expanded above, descending in a gentle curve, the margins slightly converging, receding below; aperture subovate.

Alt. 11, diam. maj. 12·5, diam. min. 10·25 mm.

Aperture: alt. 6, diam. 5·75 mm.

*Hab.* Larogi Hills, British East Africa, at an altitude of between 6000 and 7000 feet. (A. Blayney Percival.)

MIKENOELLA NEGLECTA, sp. n. (Pl. II. fig. 27.)

Shell globosely turbinate, narrowly perforate, thin, unicolorous, pale yellowish brown; whorls  $5\frac{1}{2}$ , regularly increasing, marked only with slightly arcuate, transverse growth-plicæ; base of shell convex; umbilicus very narrow, almost covered by the outward reflexion of the columella; columella broadly outwardly reflexed above, very narrowly so below; aperture subovate.

Alt. 11, diam. maj. 13·25 (nearly) mm.

Aperture: alt. 7·5, diam. 6·5 mm.

*Hab.* Kiduha, S.W. Uganda. (Robin Kemp.)

#### URGUESSELLA, gen. nov.

Shell perforate, thin, corneous, depressed, *hirsute*, the last whorl *descending rather rapidly in front*.

Genotype: *U. urguesensis* Preston.

The following two species should undoubtedly be included in *Urguessella*:—

*Trachycystis nigrotincta* Preston, from British East Africa, Rev. Zool. Africaine, vol. i. p. 325, pl. xvii. fig. 9.

*T. fusco-olivacea* Smith, from Nyassaland, Proc. Zool. Soc. London, 1899, p. 585.

URGUESSELLA URGUESSENSIS, sp. n. (Pl. III. figs. 25, 25 a, 25 b.)

Shell perforate, turbinate, with subplanulate spire, yellowish brown, covered with a *hirsute* periostracum, the hairs being about one millimetre in length, yellow in colour, placed at a moderate distance apart and arranged in very oblique rows; whorls  $4\frac{1}{2}$ , regularly increasing, the last descending in front; suture impressed; base of shell somewhat convex; umbilicus rather narrow, deep; columella triangularly outwardly expanded above, descending in a rounded curve; labrum white, thin, very narrowly outwardly expanded and reflexed; aperture somewhat rectangularly ovate, on the parietal wall; just without the aperture, where the hairs no longer appear, the surface of the shell is seen to be marked with transverse pustulous riblets.

Alt. 5·25, diam. maj. 9·25, diam. min. 8 mm.

Aperture: alt. 3·75, diam. 4 mm.

*Hab.* Urguess, British East Africa. (A. Blayney Percival.)

*URGUESSELLA* ESAU, sp. n. (Pl. III. fig. 26.)

Shell allied to *U. urguessensis* Preston, but differing considerably from that species in its thinner texture, smaller size, more reddish colour, less planulate spire, subangulate last whorl, and much finer and shorter hairs, which are arranged in very oblique rows, but running at a much less acute angle to the suture than in *U. urguessensis*; the columella is also higher and more angularly curved, while the aperture is roundly ovate.

Alt. 4·75, diam. maj. 9, diam. min. 7·25 mm.

Aperture: alt. 3·75, diam. 3·75 mm.

*Hab.* Urguess, British East Africa. (A. Blayney Percival.)

*URGUESSELLA* CAPILLATA, sp. n. (Pl. III. fig. 28.)

Shell suborbicular, depressed, with almost planulate spire, thin, pale reddish brown; whorls 4, regularly increasing, the last descending in front, sculptured with corrugated, closely-set, obliquely arcuate, transverse plicæ, bearing at intervals broad bristly hairs; suture impressed; base of shell slightly convex; umbilicus moderately wide, deep; columella broadly outwardly reflexed above and diffused into a thin, ill-defined, glassy, parietal callus, descending in a vertical curve; aperture obliquely sub-lunate.

Alt. 3·25, diam. maj. 7, diam. min. 6 mm.

Aperture: alt. 3, diam. 2·5 mm.

*Hab.* Burunga, Mount Miken, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

*URGUESSELLA* CUTICULARIS, sp. n. (Pl. III. fig. 27.)

Shell thin, suborbicular, with depressed spire, covered with a shortly hispid, dark brown periostracum; whorls  $4\frac{1}{2}$ , regularly increasing, marked with very oblique, arcuate, transverse plications, the last whorl angulate at the periphery; suture impressed; base of shell rather inflated; umbilicus rather broad, open, deep; columella broadly outwardly expanded above, descending in an oblique curve; labrum simple; aperture subrectangular.

Alt. 4, diam. maj. 7, diam. min. 6 mm.

Aperture: alt. 3·5, diam. 3 mm.

*Hab.* Malasanji, S.W. Uganda. (Robin Kemp.)

*TROCHOZONITES* BUHAMBAËNSIS, sp. n. (Pl. II. fig. 23.)

Shell acutely conic, pale brown, somewhat polished; whorls 7, slightly convex, the first three somewhat slowly increasing in breadth, smooth, the remainder rather rapidly increasing, sculptured with coarse, oblique, transverse riblets, the last whorl strongly carinate at the periphery; suture impressed, very narrowly margined; base of shell nearly smooth; umbilicus narrow and very deep, partly concealed by the reflexion of the columella margin; columella margin outwardly expanded above,

vertically descending; labrum acute, simple; aperture irregularly subrectangular.

Alt. 7, diam. maj. 6.25, diam. min. 5.25 mm.

Aperture: alt. 2.75, diam. 2.25 mm.

*Hab.* Buhamba, near Lake Kivu, Belgian Congo. (Robin Kemp.)

*TROCHOZONITES EXPATRIATA*, sp. n. (Pl. II. fig. 21.)

Shell conical, with obtuse apex and very slightly constricted sides, very thin, reddish brown, glossy; whorls 6, the last two rather convex, the last acutely carinate at the periphery, sculptured with coarse, oblique growth-ridges; suture faintly incised, narrowly callously margined above; base of shell nearly planulate; umbilicus very narrow, almost entirely concealed by the outward expansion of the columella; columella margin descending in a very slight and very oblique curve; labrum simple; aperture subrectangular.

Alt. 6, diam. maj. 6.5, diam. min. 6 mm.

Aperture: alt. 1.5, diam. 3 mm.

*Hab.* Burunga, Mount Mikeno, Belgian Congo, at an altitude of 6000 feet. (Robin Kemp.)

In form much resembling the species of the genus inhabiting West Africa.

*TROCHOZONITES KEMPI*, sp. n. (Pl. II. fig. 22.)

Shell moderately small, conic, with very laterally compressed spire, in dead condition yellowish grey, somewhat iridescent, polished, shining; whorls  $6\frac{1}{2}$ , the first three and a half convex, the remainder flattened, sloping, the last acutely carinate at the periphery, sculptured with closely-set, oblique, transverse striae; suture linear, very narrowly margined above; base of shell slightly convex; umbilicus narrow, deep; columella somewhat outwardly expanded, obliquely descending; labrum simple; aperture curvedly subrectangular.

Alt. 5.25, diam. maj. 6.75, diam. min. 6.5 mm.

Aperture: alt. 2, diam. 3 mm.

*Hab.* Buhamba, near Lake Kivu, Belgian Congo. (Robin Kemp.)

*TROCHOZONITES SUTURALIS*, sp. n. (Pl. II. fig. 24.)

Shell rimate, turritely turbinate, somewhat laterally compressed below, thin, olivaceous; whorls  $6\frac{1}{4}$ , regularly increasing, smooth but for very oblique, transverse growth-lines; suture impressed, bearing, especially on the lower part of the shell, an erect, somewhat callously thickened ridge, which appears as a carina on the last whorl; perforation very narrow, almost concealed by the exceedingly narrow outward reflexion of the columella; columella thickened, outwardly reflexed and vertically descending above, obliquely descending below, very slightly inwardly bulging in the

median region; labrum acute, receding below, advancing above; aperture subrectangular.

Alt. 7, diam. maj. 6·25, diam. min. 6 mm.

Aperture: alt. 3, diam. 2·5 mm.

*Hab.* Urguess, British East Africa. (A. Blayney Percival.)

PERCIVALIA, gen. nov.

Shell thin, perforate, compactly coiled, turbinate, sculptured on the spire with transverse wrinkle-like plications, which are absent on the bases.

Genotype: *P. nyiroënsis* Preston.

PERCIVALIA NYIROËNSIS, sp. n. (Pl. I. figs. 12 a, 12 b.)

Shell depressedly turbinate, polished, shining, pale greenish yellow, painted with a broad, supersutural, spiral band of chestnut, which appears as a superperipheral band on the last whorl; whorls 6, the first two slightly exserted, the remainder flattish, the last angular at the periphery, sculptured with oblique, transverse, arcuate, wrinkle like plicæ; suture impressed, narrowly margined above; base of shell somewhat convex, sculptured only with very fine, indistinct, wavy, spiral striæ; umbilicus very narrow, partly concealed by the twisted columella; columella somewhat sharply twisted above, very obliquely descending; labrum simple; aperture rather obliquely sublunate.

Alt. 6, diam. maj. 10, diam. min. 9·25 mm.

Aperture: alt. 5, diam. 4·75 mm.

*Hab.* Mount Nyiro, to the south of Lake Rudolph, at an altitude of 8300 feet. (A. Blayney Percival.)

LEDOULXIA CRASSIPPLICATA, sp. n. (Pl. I. figs. 1, 1 a.)

Shell depressedly turbinate, thin, light brown; whorls 5, regularly increasing, convex, shouldered above, sculptured with coarse, rather distant, obliquely arcuate, somewhat acute plications, the last whorl acutely and callously carinate at the periphery; suture impressed, narrowly callously margined above; base of shell moderately convex, smooth, without sculpture; umbilicus open, deep, sculptured with somewhat distant, wavy, revolving striæ within; columella margin broadly outwardly expanded and vertically descending above, curved below; labrum simple; aperture obliquely subrectangular.

Alt. 7, diam. maj. 11·5, diam. min. 10 mm.

Aperture: alt. 5, diam. 4·5 mm.

*Hab.* Forest to the north of Mount Kenia, British East Africa. (A. Blayney Percival.)

LEDOULXIA DECUSSATA, sp. n. (Pl. I. fig. 7.)

Shell with roundly turbinate spire, pale brownish yellow above, the colouring concentrating in an ill-defined, supersutural, reddish-brown band, showing traces of having been covered with a

chestnut periostracum; whorls 6, regularly increasing, the extreme apex smooth, the second whorl sculptured only with slightly distant and very oblique, coarse, transverse striæ, the remaining whorls sculptured with fine, closely-set, transverse striæ crossed by fine spirals, thus presenting a finely decussate appearance, the last whorl rather strongly carinate at the periphery; base of shell polished, shining, dark brownish yellow, somewhat granulate and sculptured with fine, wavy, moderately closely-set, revolving striæ; suture impressed, very narrowly callously margined above; umbilicus rather narrow, deep; columella outwardly expanded in the upper region, vertically descending above, then bulging obliquely inwards and very gently and obliquely curved below; labrum simple; aperture broadly and somewhat compressedly sublunate.

Alt. 11, diam. maj. 16, diam. min. 14.75 mm.

Aperture: alt. 7, diam. 7.75 mm.

*Hab.* Larogi Hills, British East Africa. (A. Blayney Percival.)

*LEDLOULXIA ELGONENSIS*, sp. n. (Pl. I. fig. 4.)

Shell allied to *Martensia jenyysi* Pfr.\*, of which it may ultimately prove to be a subspecies; it is, however, much more depressed than is that species, the spiral sculpture, both on the base and on the whorls, is also more developed, and the columella descends much more obliquely.

Alt. 7.75, diam. maj. 13, diam. min. 11.25 mm.

Aperture: alt. 5.75, diam. 5.75 mm.

*Hab.* Mount Elgon, Uganda. (C. W. Woodhouse.)

*LEDLOULXIA EUSSOËNSIS*, sp. n. (Pl. I. fig. 2.)

Shell rather solid, perforate, somewhat depressedly turbinate, cream-coloured, flecked here and there with greyish black and ornamented with a very narrow, interrupted, peripheral band of the same; whorls 6, sculptured with very closely-set, coarse, oblique, arcuate striæ; the last whorl obtusely angled at the periphery; base of shell marked with lines of growth and sculptured with irregular, wavy, revolving, scratch-like striæ; suture well impressed; umbilicus narrow, deep, slightly overhung by the outward expansion of the columella; columella descending in a curve; labrum simple; aperture obliquely sublunate.

Alt. 13.75, diam. maj. 19, diam. min. 16.5 mm.

Aperture: alt. 9, diam. 8 mm.

*Hab.* Eusso Nyiro, British East Africa. (Robin Kemp.)

*LEDLOULXIA JINGAËNSIS*, sp. n. (Pl. I. fig. 6.)

Shell broadly turbinate, thin, straw-colour, painted with a narrow, supersutural, spiral band of reddish purple; whorls 6, regularly increasing, rather convex, the last acutely and callously carinate at the periphery; sculptured with fine, closely-set,

\* Proc. Zool. Soc. London, 1845, p. 131.

oblique, slightly arcuate, transverse costulae; suture impressed, narrowly callously margined above; base of shell moderately convex, somewhat polished, marked with lines of growth and sculptured with fine, wavy, revolving striae; umbilicus narrow, deep; columella descending in an oblique curve, outwardly expanded above and diffused into a very thin, almost imperceptible, well-defined, parietal callus, which reaches the upper margin of the labrum; labrum simple, acute; aperture obliquely, compressedly subulate.

Alt. 9, diam. maj. 14, diam. min. 12·25 mm.

Aperture: alt. 5·75, diam. 6·25 mm.

*Hab.* Jinga on Lake Victoria Nyanza, S.W. Uganda; also taken at Entebbe and Kampala in the same district. (Robin Kemp.)

*LEDOULXIA LEVISTRIATA* (Preston \*), var. *NYERIENSIS*, var. n. (Pl. I. fig. 3.)

Shell differing from the typical form in its rather broader shape and proportionately slightly less acuminate spire, and in the colour, which in the present variety is of a yellowish hue.

Alt. 12, diam. maj. 19·75, diam. min. 17 mm.

Aperture: alt. 8·5, diam. 9·5 mm.

*Hab.* Nyeri, British East Africa. (Robin Kemp.)

*LEDOULXIA ADJACENS*, sp. n. (Pl. I. fig. 8.)

Shell differing from *L. levistriata* (Preston) in its more depressed form, rather narrower perforation, and slightly broader aperture; the transverse sculpture on the whorls is finer and the spiral sculpture on the base rather coarser and considerably more distant; the colour of the present species is yellowish brown, and the carina and sutural margination not so marked as in *L. levistriata*.

Alt. 11·5, diam. maj. 18, diam. min. 15·5 mm.

Aperture: alt. 8, diam. 8·25 mm.

*Hab.* Mount Kenangop, Aberdare Range, British East Africa. (Robin Kemp.)

*LEDOULXIA MARSABITENSIS*, sp. n. (Pl. I. fig. 5.)

Shell allied to *Martensia permanens* Smith†, but smaller, darker in colour, more narrowly umbilicate, more closely and coarsely sculptured, and with proportionately higher spire than has that species.

Alt. 9·75, diam. maj. 15, diam. min. 13·5 mm.

Aperture: alt. 7, diam. 6·25 mm.

*Hab.* Northern slopes of Mount Marsabit, British East Africa. (A. Blayney Percival.)

\* *Martensia levistriata* Preston, Rev. Zool. Africaine, Bruxelles, iii. p. 48, pl. v. fig. 2.

† J. Malac. viii. p. 94.

## FALLOONELLA, gen. nov.

Shell depressed or depressedly conoid, perforate, closely and almost laminiferously striate above, polished on the base, suturally callously margined, and carinate at the periphery.

Genotype: *F. exquisita* Preston.

## FALLOONELLA EXQUISITA, sp. n. (Pl. I. figs. 9, 9a, 9b.)

Shell depressedly turbinate, suborbicular, thin, somewhat diaphanous and shining, chestnut-coloured; whorls  $5\frac{1}{2}$ , the earlier whorls smooth, the later whorls sculptured with moderately fine and very closely-set, oblique, arcuate costulæ; suture bearing a sulcate raised ridge, which appears on the last whorl as a yellowish raised peripheral carina; base of shell polished, shining, showing radiate growth-ridges and sculptured only with very fine, wavy, and closely-set revolving striæ; umbilical area greenish olive, the perforation being deep and very narrow; columella oblique, somewhat curved, very narrowly outwardly expanded above, and diffusing into a thin, minutely granular, outwardly spreading, well-defined callus, which reaches the upper margin of the labrum; labrum simple, acute; aperture obliquely and somewhat broadly sublunate.

Alt. 5, diam. maj. 9.75, diam. min. 8.75 mm.

Aperture: alt. 4.25, diam. 4.5 mm.

*Hab.* Urguess, British East Africa. (A. Blayney Percival.)

## FALLOONELLA EXQUISITA GÜDEI, subsp. n. (Pl. I. fig. 10.)

Shell differing from typical *F. exquisita* Preston in having one whorl more, in its less depressed form, rather finer oblique costulæ on the spire, and in the sutural ridge which is also considerably finer, the perforation is rather less narrow, the columella is less curved and more oblique, and the aperture is rather narrower in proportion to its height.

Alt. 6.75, diam. maj. 11 (nearly), diam. min. 9.75 mm.

Aperture: alt. 5.25, diam. 5 mm.

*Hab.* Larogi Hills, British East Africa. (A. Blayney Percival.)

## FALLOONELLA LAROGIENSIS, sp. n. (Pl. I. figs. 11a, 11b.)

Shell perforate, depressedly turbinate, dark livid flesh-colour above, covered with a chestnut periostracum; whorls  $5\frac{1}{2}$ , flattish, regularly, but not rapidly, increasing, the first two and a half spirally sulcate, the remainder sculptured with moderately coarse, not very regular, but wavy, oblique, transverse riblets, presenting through a lens a slightly corrugated appearance; suture lightly impressed, bearing a somewhat coarse, thread-like, cream-coloured ridge, which appears as a rather sharp peripheral carina on the last whorl; base of shell slightly polished, whitish yellow, sculptured with distant, revolving, microscopic, scratch-like striæ; perforation narrow, deep; columella triangularly, outwardly expanded above, obliquely descending in a slight curve; labrum

simple, receding below ; aperture obliquely and depressedly crescentic.

Alt. 6, diam. maj. 11·75, diam. min. 10 mm.

Aperture : alt. 5·25, diam. 5 mm.

*Hab.* Larogi Hills, British East Africa, at an altitude of from 6000 to 7000 feet. (A. Blayney Percival.)

## EXPLANATION OF THE PLATES.

### PLATE I.

- Figs. 1, 1 *a.* *Ledoulxia crassiplicata*, sp. n.  
 2. " *ensoënsis*, sp. n.  
 3. " *levistriata* (Preston), var. *nyeriensis*, var. n.  
 4. " *elgonensis*, sp. n.  
 5. " *marsabitensis*, sp. n.  
 6. " *jingaënsis*, sp. n.  
 7. " *decussata*, sp. n.  
 8. " *adjacens*, sp. n.  
 9, 9 *a.*, 9 *b.* *Falloomella exquisita*, sp. n.  
 10. " *gudei*, subsp. n.  
 11 *a.*, 11 *b.* " *larogiensis*, sp. n.  
 12 *a.*, 12 *b.* *Percivalia nyiroënsis*, sp. n.  
 13 *a.*, 13 *b.*, 13 *c.* *Nakuruëlla soror*, sp. n.  
 14. *Burungaëlla mutandana*, sp. n.  
 15. " *imperfôrata*, sp. n.  
 16. " *buhambaënsis*, sp. n.  
 17 *a.*, 17 *b.*, 17 *c.* " *oscitans*, sp. n.  
 18. *Blayneiyella microspiralis*, sp. n.  
 19 *a.*, 19 *b.*, 19 *c.* " *percivali*, sp. n.  
 20. " *purpureocincta*, sp. n.  
 21. " *kisengiënsis*, sp. n.  
 22, 22 *b.*, 22 *c.* *Larogiella venatoris*, sp. n.  
 23. " *malasanjiënsis*, sp. n.

### PLATE II.

- Figs. 1. *Larogiella angulifera*, sp. n.  
 2. " *kombaënsis*, sp. n.  
 3. " *fonticula*, sp. n.  
 4. *Africarion oscitans*, sp. n.  
 5 *a.*, 5 *b.* *Elgonella flavidula*, sp. n.  
 6 *a.*, 6 *b.* " *angustior*, sp. n.  
 7 *a.*, 7 *b.* " *discolorata*, sp. n.  
 8 *a.*, 8 *b.* " *oribates*, sp. n.  
 9 *a.*, 9 *b.*, 9 *c.* " *eulotæformis*, sp. n.  
 10 *a.*, 10 *b.* " *robini*, sp. n.  
 11 *a.*, 11 *b.* " *brunnea*, sp. n.  
 12 *a.*, 12 *b.* " *sobrina*, sp. n.  
 13. *Africarion copiosa*, sp. n.  
 14. " *marsabitensis*, sp. n.  
 15. " *orestias*, sp. n.  
 16. " *kiduhaënsis*, sp. n.  
 17. " *spatiosa*, sp. n.  
 18. " *kagambahensis*, sp. n.  
 19. " *tenebrosa*, sp. n.  
 20. " *concavospira*, sp. n.  
 21. *Trochozonites expatriata*, sp. n.  
 22. " *kempi*, sp. n.  
 23. " *buhambaënsis*, sp. n.  
 24. " *suturalis*, sp. n.  
 25. *Mikenoëlla elevata*, sp. n.  
 26 *a.*, 26 *b.*, 26 *c.* " *ahena*, sp. n.  
 27. " *neglecta*, sp. n.

## PLATE III.

|       |                 |  |
|-------|-----------------|--|
| Figs. | 1.              | <i>Gudeëlla inclinans</i> , sp. n.       |
|       | 2.              | " <i>usitata</i> , sp. n.                |
|       | 3.              | " <i>multistriata</i> , sp. n.           |
|       | 4.              | " <i>tribulationis</i> , sp. n.          |
|       | 5.              | " <i>pallidior</i> , sp. n.              |
|       | 6.              | " <i>bartaënsis</i> , sp. n.             |
|       | 7.              | " <i>gerstenbrandti</i> , sp. n.         |
|       | 8.              | " <i>inclinans</i> , sp. n.              |
|       | 9.              | " <i>consobrina</i> , sp. n.             |
|       | 10.             | " <i>kampalaënsis</i> , sp. n.           |
|       | 11.             | " <i>mukandaënsis</i> , sp. n.           |
|       | 12.             | " " var. <i>mutandana</i> , var. n.      |
|       | 13.             | " <i>woodhousei</i> , sp. n.             |
|       | 14.             | " <i>densesculpta</i> , sp. n.           |
|       | 15.             | " <i>iridescens</i> , sp. n.             |
|       | 16.             | " <i>masakaënsis</i> , sp. n.            |
|       | 17.             | " <i>urguessensis</i> , sp. n.           |
|       | 18.             | " <i>consueta</i> , sp. n.               |
|       | 19.             | " <i>elgonensis</i> , sp. n.             |
|       | 20.             | " <i>aranea</i> , sp. n.                 |
|       | 21.             | " <i>inflata</i> , sp. n.                |
|       | 22.             | " <i>marsabitensis</i> , sp. n.          |
|       | 23.             | " <i>mime</i> , sp. n.                   |
|       | 24.             | " <i>nemorum</i> , sp. n.                |
|       | 25, 25 a, 25 b. | <i>Urguessella urguessensis</i> , sp. n. |
|       | 26.             | " <i>esau</i> , sp. n.                   |
|       | 27.             | " <i>cuticularis</i> , sp. n.            |
|       | 28.             | " <i>capillata</i> , sp. n.              |







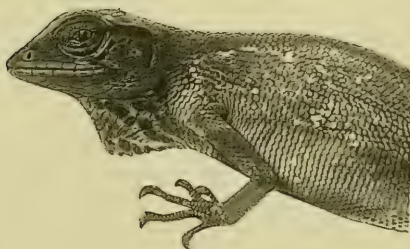
2.



1



3a.

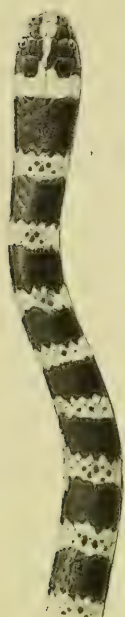


3.

*J. Green photo del.*

1. ATELOPUS SPURRELLI. 2. LEPIDOBLEPHARIS INTERMEDIUS.  
3. POLYCHRUS SPURRELLI.





3.



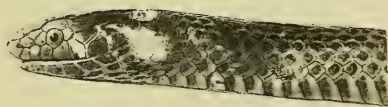
1.



1a.



3a.



2a



2.

*J. Green photo del.*

1. LEPTOPHIS BREVIOR. 2. HOMALOCRANIUM NIGRUM.  
3. ELAPS SPURRELLI.

44. On a second Collection of Batrachians and Reptiles made by Dr. H. G. F. Spurrell, F.Z.S., in the Choco, Colombia. By G. A. BOULENGER, F.R.S., F.Z.S.\*

[Received May 20, 1914; Read June 9, 1914.]

(Plates I. & II.†)

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Since the publication of the account of Dr. Spurrell's Collection of Batrachians and Reptiles from the Choco‡, the British Museum has received a further important series of these animals presented by the same energetic collector. All were obtained at or near Peña Lisa, Condoto. In the following list I have only enumerated the species not mentioned in the previous list.

## BATRACHIA.

### CAUDATA.

1. SPELERPES PARVIPES Peters.

### ECAUDATA.

2. BUFO CONIFERUS Cope.
3. HYLODES RANIFORMIS Blgr.
4. ATELOPUS SPURRELLI, sp. n. (Pl. I. fig. 1.)

Habit slender. Head a little longer than broad, one-third the length from snout to vent; snout obtusely pointed, prominent, obliquely truncate, a little longer than the eye; loreal region nearly vertical, slightly concave; nostril near the tip of the snout; interorbital space as broad as the upper eyelid. Fore limb slender, as long as the trunk; fingers webbed at the base, with swollen tips; first finger very short; a flat palmar tubercle; no subarticular tubercles. Hind limb slender; the tibio-tarsal

\* Published by permission of the Trustees of the British Museum.

† For explanation of the Plates see p. 817.

‡ P.Z.S. 1913, p. 1019.

articulation reaches the eye; tibia half the length of head and body; toes half-webbed, inner very short but perfectly distinct; the tips blunt; metatarsal and subarticular tubercles very indistinct. Green above, with small black spots and large symmetrical black markings, viz.: a streak on the canthus rostralis; an **X** on the head and between the shoulders, the anterior branches extending on the upper eyelids, the posterior confluent with a lateral band which is expanded on the temple and extends to the groin; a spade-shaped figure on the sacral region; a pair of large spots above the waist, and cross-bars on the limbs; lower parts white, with round black spots. Male with brown rugosities on the inner finger.

From snout to vent 24 mm.

A single specimen.

## REPTILIA.

### CHELONIA.

#### 1. CHELYDRA ROSSIGNONI Bocourt.

This species was only known from Southern Mexico, Guatemala, and Western Ecuador.

### LACERTILIA.

#### 2. THECADACTYLUS RAPICAUDA Houtt.

#### 3. LEPIDOBLEPHARIS INTERMEDIUS, sp. n. (Pl. I. fig. 2.)

Scaling as in *L. peraccae* Blgr., form more as in *L. festae* Peracca. Granules of upper parts very small, largest on the snout. Snout pointed, much longer than the orbit; rostral with median cleft, and concave above, as in the two other species; symphysial likewise very large, with two clefts behind; five upper and four lower labials, first very large. Brown above, with darker and lighter variegations; a whitish streak across the nape; lower parts pale brown, throat whitish.

|                     |        |
|---------------------|--------|
| Total length .....  | 63 mm. |
| Head .....          | 8 "    |
| Width of head ..... | 4 "    |
| Body .....          | 21 "   |
| Fore limb .....     | 8 "    |
| Hind limb .....     | 11 "   |
| Tail .....          | 34 "   |

Two specimens.

#### 4. ANOLIS PALMERI Blgr.

#### 5. POLYCHRUS SPURRELLI, sp. n. (Pl. I. figs. 3, 3 a.)

Snout obtusely pointed; nostril equally distant from the orbit and from the tip of the snout; eye-opening nearly as large as the

tympanum : upper head-scales smooth or feebly striated ; scales of supraorbital semicircles in contact with each other in the middle or separated by one series of scales ; supraocular scales small ; labials striated, five upper and four lower to below centre of eye ; symphysial with a median cleft posteriorly. Gular scales much larger than ventrals, feebly striated ; no gular denticulation or crest. Scales on body feebly unicarinate, dorsals a little larger than laterals and ventrals. Limbs moderately elongate, the scales feebly unicarinate. 12 to 15 femoral pores on each side. Tail very long and round, with rather strongly unicarinate scales. Reddish or purplish brown, posterior part of belly and anal region greenish ; A-shaped darker cross-bands may be present on the body ; a blackish horizontal line behind the eye and another, oblique, from below the centre of the eye ; base of tail and base of thigh with a white streak.

|                     |         |
|---------------------|---------|
| Total length .....  | 360 mm. |
| Head .....          | 23 "    |
| Width of head ..... | 15 "    |
| Body .....          | 67 "    |
| Fore limb .....     | 43 "    |
| Hind limb .....     | 57 "    |
| Tail .....          | 270 "   |

Two female specimens.

#### 6. IGUANA TUBERCULATA Laur.

### O P H I D I A.

#### 7. BOA IMPERATOR Daud.

#### 8. EPICRATES CENCHRIS L.

#### 9. DRYMOBIUS BODDAERTII Sentz.

#### 10. PHRYNONAX PÆCILONOTUS Gthr.

#### 11. SPILOTES PULLATUS L.

#### 12. SPILOTES MEGALOLEPIS Gthr.

This rare snake is only known from N.W. Ecuador and S.W. Colombia, where specimens were obtained by Mr. Palmer.

#### 13. COLUBER CORAIS L.

#### 14. LEPTOPHIS BREVIOR, sp. n. (Pl. II, figs. 1, 1a.)

Rostral a little broader than deep, just visible from above ; internasals as long as broad, a little shorter than the præfrontals ; frontal once and three-fourths as long as broad, as long as its distance from the end of the snout, shorter than the parietals ;

nasal elongate, entire; no loreal; præfrontal in contact with the second and third upper labials; one præocular, in contact with the frontal; two postoculars; temporals 1 + 2; eight upper labials, fourth and fifth entering the eye; five lower labials in contact with the anterior chin-shields, which are shorter than the posterior. Scales in 15 rows, finely striated and strongly keeled, the two outer rows smooth. Ventrals feebly angulate laterally, 139; anal divided; subcaudals 127. Scales partly green partly brownish, with golden sheen; upper lip white; a black line on each side of the head, above the labials, passing through the eye; lower parts pinkish, with mother-of-pearl sheen.

Total length 580 mm.; tail 245.

A single female specimen.

Well distinguished, among the species with keeled scales and no loreal, by the low number of ventral shields.

15. *XENODON COLUBRINUS* Gthr.

16. *RHADINÆA DECORATA* Gthr.

A young specimen, referred with some doubt to this species.

17. *OXYRHOPUS PETOLARIUS* L.

18. *RHINOBOOTHRYUM LENTIGINOSUM* Scop.

19. *OXYBELIS BREVIROSTRIS* Cope.

20. *OXYBELIS ACUMINATUS* Wied.

21. *HOMALOCRANIUM NIGRUM*, sp. n. (Pl. II. figs. 2, 2 a.)

Eye two-fifths the length of the snout. Rostral nearly twice as broad as deep, scarcely visible from above; internasals half as long as the præfrontals; frontal pentagonal, a little longer than broad, more than twice as broad as the supraocular, a little longer than its distance from the end of the snout, much shorter than the parietals; nostril between the nasals, the posterior in contact with the præocular; a single postocular; temporals 1 + 1; seven upper labials, third and fourth entering the eye; first lower labial in contact with its fellow behind the symphysial; four lower labials in contact with the anterior chin-shields, which are longer than the posterior. Scales in 15 rows. Ventrals 143; anal divided; subcaudals 63. Black above and beneath; a pair of round yellow spots close together on the occiput; a larger, oblique spot on each side of the latter, behind the angle of the mouth; a narrow, oblique yellow spot on the fifth and sixth upper labials, and a very small round one on the second upper labial.

Total length 175 mm.; tail 48.

22. *ELAPS SPURRELLI*, sp. n. (Pl. II. figs. 3, 3 a.)

Eye nearly as long as its distance from the mouth. Rostral much broader than deep, scarcely visible from above; frontal broader than the supraocular, once and a half as long as broad, longer than its distance from the end of the snout, shorter than the parietals; latter as long as their distance from the end of the snout; one præ- and two postoculars; temporals 1 + 1; seven upper labials, third a little deeper but not larger than the fourth, third and fourth entering the eye; four lower labials in contact with the anterior chin-shields, which are as long as the posterior. Scales in 15 rows. Ventrals 232; anal divided; subcaudals 36. 52 black annuli separated by white areas on the body and by red on the tail; the first annulus, on the nape, much broader than the others, which are narrower than the white interspaces on the belly and broader on the back; a few small black spots between the black rings on the back; sides of head, as far back as the second temporal and the middle of the parietal, black, with a white spot on the second, third, and fourth upper labials; a white middle line on the head, forming a **I** with a broad white bar across the occiput.

Total length 230 mm.; tail 20.

A single female specimen.

23. *LACHESIS SCHLEGELII* Berth.

## EXPLANATION OF THE PLATES.

## PLATE I.

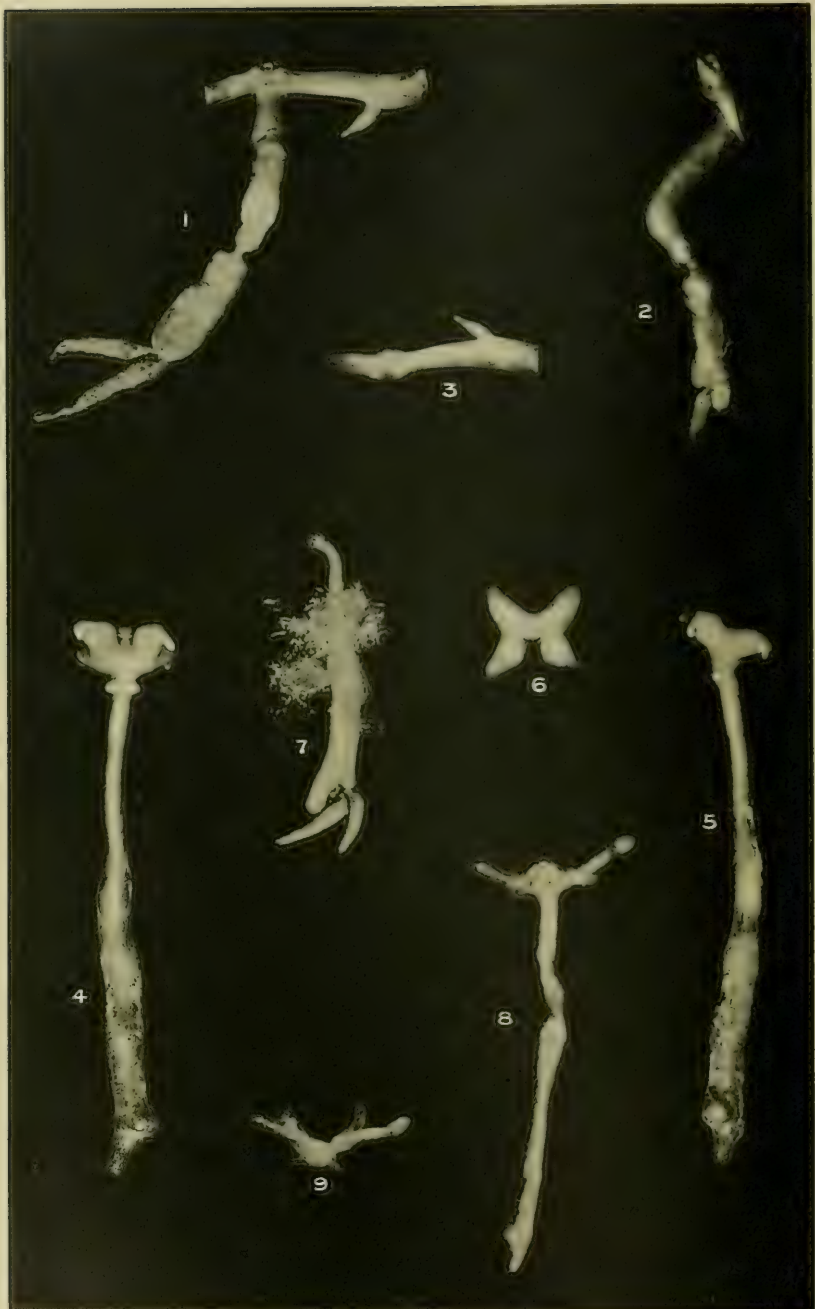
- Fig. 1. *Atelopus spurrelli*, p. 813. Nat. size, upper and lower views.  
 2. *Lepidoblepharis intermedius*, p. 814.  $1\frac{1}{2}$  nat. size.  
 3, 3 a. *Polychrus spurrelli*, p. 814. Side view of head and anterior part of body, nat. size, and upper view of head,  $1\frac{1}{2}$  nat. size.

## PLATE II.

- Figs. 1, 1 a. *Leptophis brevior*, p. 815. Upper view of head and anterior part of body, nat. size, and side view of head,  $\times 2$ .  
 2, 2 a. *Homalocranium nigrum*, p. 816. Upper view of head and anterior part of body,  $\times 2$ , and side view,  $\times 3$ .  
 3, 3 a. *Elaps spurrelli*, p. 817. Upper and lower views of head and anterior part of body,  $\times 2$ , and side view,  $\times 3$ .







W.A.C. photo.

London Stereoscopic Co., imp.

1-3. LERNAEOCERA DICERACEPHALA.

4-7. L. HAPLOCEPHALA. 8, 9. L. TEMNOCEPHALA.

45. Zoological Results of the Third Tanganyika Expedition, conducted by Dr. W. A. Cunningham, 1904-1905.—  
Report on the Parasitic Eucoppeoda. By WILLIAM A.  
CUNNINGTON, M.A., Ph.D., F.Z.S.

[Received May 4, 1914: Read June 9, 1914.]

(Plate I.\* & Text-figure 1.)

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1. Introduction.

In addition to the parasitic Copepods belonging to the order Branchiura, the collections made during the Third Tanganyika Expedition contain a very few specimens of parasitic Eucoppeoda belonging to the family Lernæidæ†. While there are many parasitic forms of Eucoppeoda, comparatively few of them have been found on freshwater hosts, and these, perhaps, have received less attention than the forms infesting marine fishes. In the family Lernæidæ, the genus *Lernæocera*‡ is the only one which is known to occur in fresh water, and it is to this well-known genus that our specimens have been referred.

Through the kindness of Dr. Calman I have been allowed to examine a good many examples of *Lernæocera* from the Nile, which belong to the British Museum§. Since these specimens have not been examined or described, and since they add considerably to the scanty material which we possess from the African continent, an account of them is included in the present paper. So far as I am aware, the existence of the genus in Africa has never been put on record before, the species hitherto known being either European or American. The following is

\* For explanation of the Plate, see p. 829.

† Certain parasitic Eucoppeoda belonging to the family Ergasilidæ were obtained by the Expedition, in addition to the forms described in this paper. They were taken in the last free stage, in tow-nettings associated with non-parasitic Copepods, and in consequence were dealt with by Prof. G. O. Sars in his paper on the Copepoda of the Third Tanganyika Expedition (Proc. Zool. Soc. 1909, p. 63).

‡ The generic name is written throughout in the form in which it is almost universally quoted, and *not* as it was originally spelled by Blainville, viz. *Lerneocera*. The word is derived from the Linnæan genus *Lernæa*.

§ By the courtesy of the authorities of the Berlin Museum, specimens of *L. cyprinacea* and *L. esocina* (the latter, one of the original examples studied by von Nordmann) were lent to the British Museum for the purpose of comparison with the forms described here. I am particularly indebted to Dr. E. Vanhöffen for the trouble he has taken in the matter.

a list of the African forms described for the first time in this paper:—

LAKE TANGANYIKA.

*Lernæocera diceracephala*.

*Lernæocera haplocephala*.

RIVER NILE.

*Lernæocera haplocephala*.

*Lernæocera temnocephala*.

For the purpose of illustration, I have made use of photographs taken from the actual specimens themselves. They are by no means easy objects to photograph, but in spite of imperfections, the figures will make clear the various external characters which have been used for the systematic descriptions. I have to thank Prof. Dendy, of King's College, London, for permission to do this photographic work in his laboratory.—The plan has been adopted of giving in each case a view of the head and cephalic arms from above. This was done by von Nordmann, one of the earliest writers on the genus, but his example has not been widely copied. It needs some trouble to support the specimens in the position necessary to secure such a view, but the figures obtained illustrate the nature of the head region far better than any others could do.

2. *Systematic Notes and Description of New Species.*

The literature which deals with the different species of the genus *Lernæocera* is somewhat scattered and not always easy to obtain. Although a list of the known species with synonyms is given by Bassett-Smith\*, it is marked by material inaccuracies, so that it would seem worth while at this point to include a list which may be useful to future investigators as a starting point for their researches. No attempt has been made to give an exhaustive list of the authors by whom the species have been cited, as this would take up a good deal of space and serve no useful purpose. Only those works are referred to which have a bearing on the synonymy or which contain a record of original observations.

List of described Species with Synonyms.

1. *LERNÆOCERA CYPRINACEA* † (Linnæus) ‡.

“*Lerneæa tentaculis quatuor: duobus apice lunulatis.*”

Linnæus, *Fauna Suecica*, Ed. I. 1746, p. 367, tab. ii.

*Lernæa cyprinacea* Linnæus, *Systema Naturæ*, Ed. X. 1758, p. 655.

\* Proc. Zool. Soc. 1899, p. 480.

† So far as I can ascertain, no one has ever fixed the type species or genotype of *Lernæocera*. Assuming this to be the case, in order to maintain the usage of all modern writers, I hereby select *cyprinacea* as genotype of *Lernæocera*.

‡ Parentheses enclosing the Author-citation after specific names are used in accordance with Art. 23 of the International Rules of Nomenclature.

- Lerneocera cyprinacea* Blainville, Journal de Physique, t. 95, 1822, p. 377.
- Lerneocera cyprinacea* Burmeister, Nova Acta Acad. Cæs.-Leop. Bd. 17, 1835, p. 309.
2. LERNÆOCERA ESOCINA\* Burmeister.
- Lerneocera cyprinacea* v. Nordmann, Mikrograph. Beitr. Naturgesch. wirbellosen Thiere, Heft 2, Berlin, 1832, p. 123 (non *L. cyprinacea* Linn.).
- Lerneocera esocina* Burmeister, Nova Acta Acad. Cæs.-Leop. Bd. 17, 1835, pp. 309 & 312.
- Lerneocera gasterostei* Brühl, Mitt. K. K. zool. Inst. d. Univ. Pest, 1860 (Wien), p. 1.
- Lerneocera gobina* Claus, Würzb. naturw. Zeitschr. Bd. ii. 1861, p. 11.
- Lerneocera esocina* Claus, Beobachtungen über *Lerneocera*, *Peniculus* und *Lernæa*. Marburg, 1868, p. 1.
3. LERNÆOCERA CRUCIATA Lesueur.
- Lerneocera cruciata* (? *Lerneanicus*) Lesueur, Journ. Acad. Nat. Sci. Philadelphia, vol. iii. 1824, p. 286.
4. LERNÆOCERA PHOXINACEA Krøyer.
- Lerneocera phoxinacea* Kollar MS., Krøyer, Naturhistorisk Tidsskrift, ser. 3, vol. ii., Copenhagen, 1863-64, p. 399.
5. LERNÆOCERA LAGENULA Heller.
- Lerneocera lagenula* Heller, Reise der Novara—Crustaceen (Wien, 1865), p. 246.
6. LERNÆOCERA POMOTIDIS Krøyer.
- Lerneocera pomotidis* Krøyer, Naturhistorisk Tidsskrift, ser. 3, vol. ii., Copenhagen, 1863-64, p. 397.
7. LERNÆOCERA CATOSTOMI Krøyer.
- Lerneocera catostomi* Krøyer, Naturhistorisk Tidsskrift, ser. 3, vol. ii., Copenhagen, 1863-64, p. 395.

It is perhaps well to point out here that the classification of the parasitic Eucopepoda has hardly received the attention devoted to that of free-living forms. At the same time it is clear that a satisfactory basis on which to classify the former is unusually difficult to find, on account of the extraordinary degree of modification commonly undergone by the female on the adoption of a parasitic mode of life. It is possible, indeed probable, that

\* It has been suggested by some modern writers (cf. Bassett-Smith, *op. cit.* p. 480, and Brian, 'Copepodi Parassiti dei Pesci d'Italia,' Genova, 1906, p. 79) that the species *esocina* and *cyprinacea* should be united. Their contention does not seem to rest on personal observations, but on their interpretation of the original descriptions. After an examination of the actual specimens, I have no hesitation in confirming the view of the older authors, namely that the species are perfectly distinct.

individual variations of form will be more than usually common as concerns the greatly distended bodies or the cephalic processes for attachment to the host, as the exact shape would seem without significance for the life of the parasite. Yet it is precisely such details which are employed for the purposes of classification. Thus within the limits of the genus *Lernæocera* itself it is difficult to be sure how far the specific characters employed will prove constant and therefore trustworthy, for even among the specimens that I have examined a considerable lack of uniformity has been observed.

#### Genus LERNÆOCERA Blainville.

It does not seem desirable to re-define the genus here, although the species now included in it would not strictly come under Blainville's original generic description. Indeed, his account is based upon certain misconceptions, notably the view—shared by contemporary writers—of the absence of appendages on the body, for he says “Aucune trace d'appendices au corps.” Nevertheless a number of species have been placed in this imperfectly defined genus, but it is open to question whether they should all remain there. A careful study of these forms has given me the impression that two or three of them may merit separation as distinct genera, or at least sub-genera; but without opportunities for a more comprehensive examination, it is impossible to express a very definite opinion, and the course least open to objection is to leave matters as they are.

Before proceeding to give descriptions of the new species, there remain one or two matters which need some explanation. It is characteristic of most of the species, including those which are described in this paper, that they exhibit the peculiar boot-like shape of the terminal portion of the body which was first referred to by von Nordmann\* in his account of *L. esocina*. This is produced, in the first place, by a protuberance immediately in front of the genital apertures, which forms the “heel,” and which we may call the *pre-genital prominence*. In the second place, there is generally a dorsal curvature of the hindmost portion of the body (posterior to the genital apertures and corresponding to the abdomen according to Claus), which, owing to the lateral torsion undergone by the hinder part of the body, comes to lie on one side or other of the mid-line and represents the “toe.”

This explanation of the appearance we owe to Claus†, but the matter is made yet clearer by the conceptions on torsion in the Lernæidæ quite recently put forward by Quidor‡. The latter assumes that the torsion is the direct result of the mode of fixation of the parasite and the mechanical reaction of the external medium. Admitting the probability of this statement, and admitting that the orientation of a parasite to its host is

\* *Op. cit.* p. 124.

† *Vide* “Beobachtungen über *Lernæocera*,” etc., p. 2.

‡ *Comptes Rendus Acad. Sci. Paris*, Tome 154, 1912, p. 87.

probably constant for a given species, we are furnished with an explanation of the otherwise perplexing fact that this lateral torsion may be either to right or left. It will be the one or the other according to the particular side of the host which formed the point of attachment for the parasite. Quidor, moreover, gives evidence for believing that the amount of torsion is constant for a given species, and can be used as a character of systematic value.

The appendages appear to show comparatively minor differences within the limits of this genus, and have not been appealed to for the purpose of establishing new species. Thus I have not deemed it necessary to study in detail the head appendages of my new forms, since these are by no means easy to investigate, and my material, with one exception, was very scanty. So far as I have been able to make out, there are no points of striking difference in any of the types from the arrangement which is usual in the group. Accordingly in the specific descriptions which follow, no special mention of head appendages, swimming-feet or furcal appendages is made, it being implied that these are present in the normal manner, without having any bearing on the distinctions between the species.

In addition to the photographs reproduced in the plate, the accompanying text-figure is given, showing in outline for the three new species the appearance of the head and cephalic arms from above.

Text-figure 1.



Diagram showing cephalic arms, as viewed from above.

A. *Lernaeocera diceracephala*. B. *L. haplocephala*. C. *L. temnocephala*.

In order to facilitate identification, and in order to emphasise in very concrete form the chief features which characterise the new species, a key to all the known species of *Lernaeocera* has been prepared. This did not prove a very easy task, as unfortunately it has been possible for me to examine specimens of only two of the forms which have been described. For particulars of the remaining species I have been dependent entirely upon the descriptions and figures of the authors concerned, and in such cases no more can be done than to repeat certain statements which would seem of value for key-making. Thus I am not responsible for the rather remarkable assertion that *L. catostomi* possesses three cephalic arms, which, of course, renders the head quite asymmetrical. That is a feature which enables us to

contrast the form sharply with the typical species of *Lernæocera*, and which might serve as a claim to more than specific distinction.

It might be well to indicate here, briefly, the other forms which in my judgment differ materially from the more normal members of the genus. The species *L. lagenula*, as described and figured by Heller, retains in a great measure the primitive segmentation of the body which is usually lost, and at the same time fails to show the pre-genital prominence and characteristic boot-like shape of the posterior end. It has also undergone a very slight amount of torsion. The North American form *L. pomotidis* shows, according to the figure, a complete absence of any torsion, though otherwise it might rank as a typical *Lernæocera*. Finally, it must be admitted that the form to be described below as *L. diceracephala* exhibits certain features which are non-characteristic, and one feature which is not shared by any other species of the genus. This peculiarity, to which reference is made in the specific name, is the existence of only two cephalic horns—apparently the dorsal pair—instead of four. Beyond this, the lobed nature of the body, suggestive of segmentation, and the apparent absence of any torsion, are further points of distinction.

### Key to the Species of *LERNÆOCERA*.

- a. Single pair of cephalic arms present ..... *diceracephala*.
- a'. Cephalic arms markedly asymmetrical, three in number ..... *catostomi*.
- a''. Two pairs of cephalic arms present.
  - b. Cephalic arms simple without any indication of forking.
    - c. Ventro-lateral tubercles present behind junction of arms and body ..... *haplocephala*.
    - c'. No ventro-lateral tubercles present.
      - d. Cephalic arms very long and straight; body terminating in three broadly-rounded tubercles. .... *pomotidis*.
      - d'. Cephalic arms of moderate length, curved forwards; body terminating in five rounded tubercles ..... *cruciata*.
  - b'. Cephalic arms forked.
    - c. Pre-genital prominence absent ..... *lagenula*.
    - c'. Pre-genital prominence present.
      - d. Dorsal cephalic arms simple; ventral arms with process ..... *phoxinacea*.
      - d'. Dorsal cephalic arms forked; ventral arms simple.
        - e. Ventral cephalic arms nearly as stout as dorsal arms; egg-sacs oval,  $\frac{1}{2}$ — $\frac{1}{3}$  length of body ..... *esocina*.
        - e'. Ventral cephalic arms much more slender than dorsal arms.
          - f. Dorsal cephalic arms T-shaped; egg-sacs cylindrical,  $\frac{1}{4}$ — $\frac{1}{3}$  length of body ... *cyprinacea*.
          - f'. Dorsal cephalic arms Y-shaped ..... *temnocephala*.

### 1. *LERNÆOCERA DICERACEPHALA*, sp. n. (Pl. I. figs. 1–3.)

*Description*.—(Adult female.) Cephalic arms only two in number, of considerable length and projecting laterally from the region of the head-tubercle at about right angles to the body.

The arms are dilated distally and bear, at about one-third their length from the end, a stout postero-dorsal process which is bluntly pointed. The body is bent dorsally through a considerable angle at a little less than one-half its length from the head. It is not uniform in diameter, but shows a marked constriction at about the middle and an otherwise irregular contour which may indicate disappearing segmentation. Pre-genital prominence not very conspicuous, simple or slightly bilobed; terminal portion of body not upturned and rotated very little, if at all. The egg-sacs are long and tapering, about two-fifths length of body. They contain from four to five rows of eggs at their widest part. The eggs are slightly oval,  $14 \times 12$  mm.

Total length of complete specimen (excluding egg-sacs), 8.4 mm.\*

Length of longer egg-sac, 3.5 mm.

*Remarks.*—The two specimens on which this new species is founded are, unhappily, neither of them quite perfect. One of them, in fact, only consists of the main part of the body, without head, cephalic arms, or egg-sacs. This very incomplete individual affords, however, valuable evidence in certain respects, for the sharp bend in the body and the noticeable constriction referred to above, are equally recognisable here, so that we may assume them to be definite features of the species. The specimen on which the description mainly rests has lost a portion of one cephalic arm, but we may fairly suppose it to have been the same as the one which is whole. In text-fig. 1, the missing part has been restored for the sake of affording a comparison with the other species. It is open to question how far the lobed nature of the body, which is so conspicuous, is indicative of segmentation. The fact that the most typical members of the genus show the body dilated into an almost formless sac, might suggest that we are dealing in the present case with a less modified condition. On the other hand, the position of the four pairs of swimming-feet, which appear to have no definite relation to the body lobes, is an argument against such a belief.

The reference in the foregoing description to the terminal portion of the body, sufficiently indicates that in this form there is also complete or almost complete absence of the characteristic torsion of the body. This fact is, of course, equally displayed by the position of the swimming-feet, which are visible in a ventral view approximately in the middle line. All this implies, further, that the hinder end of the body cannot exhibit the usual boot-like shape as a consequence of deflection and rotation, as is generally the case, and yet it must be granted that the appearance in this respect is fairly typical. There is, of course, an important difference, namely that the shape in question is visible only in a lateral view, whereas it is shown in a ventral view of the more normal types as a result of the body torsion. In the present

\* This is the actual measurement of the specimen without taking into consideration its bent state. It would measure more if straightened out.

instance, then, the effect is produced rather by an incision in the region of the genital apertures than by the combination of characters which has been already fully explained.

The most striking characteristic of this species is the existence of only one pair of cephalic arms instead of two pairs. There seems little doubt from the relation they bear to the head-tubercle, that these correspond to the dorsal cephalic arms of species in which two pairs of arms are present. Such an important difference from the common type might be considered sufficient to warrant a generic distinction for this species, but I have preferred to leave it for the present in the genus *Lernæocera*.

*Occurrence*.—Sumbu, Lake Tanganyika, 13.10.04. From gill-arches of a large *Clarias mossambicus*. Two specimens, one very incomplete.

## 2. *LERNÆOCERA HAPLOCEPHALA*, sp. n. (Pl. I. figs. 4-7.)

*Description*.—(Adult female.) Cephalic arms four, of about equal size, short and stout, without any indication of forking and being so placed as to form a particularly regular cross. The dorsal arms are simple and bluntly pointed; the ventral differ from them only slightly, exhibiting an obvious swelling on their ventral aspects. The body is almost straight, unsegmented and cylindrical. The anterior third is slender, the body dilating gradually behind to become about twice as thick. Pre-genital prominence well marked, simple and not bilobed; terminal portion of body rather slightly upturned and rotated through somewhat less than 90°. Immediately behind the junction of the arms with the body, and just external to the second pair of swimming-feet, a pair of rounded tubercles are situated, which project ventro-laterally. The egg-sacs are moderately long and tapering, about one-fifth length of body. They contain from four to five rows of eggs at their widest part. The eggs are approximately round, and their diameter is about .1 mm.

Total length of largest specimen (excluding egg-sacs), 14.3 mm.

*Remarks*.—This species is represented in my material by a considerable number of specimens from different sources, which would suggest that it is a relatively common form. Unfortunately, the bulk of the specimens have suffered severely from lack of care in preservation, having been preserved apparently in the same manner as their host, or even with it, and they are in consequence greatly shrunk and shrivelled. It is thus the more satisfactory that all these can be readily identified as belonging to this species by the presence of the characteristic ventro-lateral tubercle mentioned above. The single specimen from Tanganyika, on which the description is largely based, and which is figured on Plate I., is unluckily devoid of egg-sacs, but this defect is made good in one from the Nile (fig. 7), which happens to be damaged elsewhere. The Tanganyika specimen proves also considerably longer than any of the individuals from the Nile, which is doubtless accounted for in part by the contracted nature of the latter.

In two tubes, each containing a number of Nile specimens, the lengths vary from 6.2–9.0 mm. and from 8.8–11.7 mm.

A careful examination showed the lateral torsion of the body to vary in direction, as was expected. Unfortunately, minute details as to the position of the parasites on the host are missing for the Nile material, so that it is impossible to test the accuracy of Quidor's assumptions in relation to this species. The individual from Tanganyika was, however, taken from the soft region at the junction of the pelvic fins,—a spot more nearly ventral than lateral. At the same time, it is hardly probable that the point of attachment was so strictly median as to preclude the possibility of lateral torsion in conformity with this view.

Fig. 7 serves also to show how strikingly these parasitic forms may in turn be covered by other organisms. In this case, the latter are Vorticellids, which infest many of these Lernæids from the Nile to such a degree as to render difficult the study of their anatomy. Among a considerable number of specimens taken on a *Polypterus senegalus*, almost all are infested, some of them as markedly as the one photographed. The region where the Vorticellids are most thickly attached is about the junction of the thin anterior third of the body with the more dilated posterior portion. It seems highly probable that the manner in which these parasitic Copepods can be so densely encrusted by such organisms (other cases are referred to in the literature of the subject), is directly related to the peculiar fact that after fixation to their host they appear no longer to undergo ecdysis\*.

*Occurrence*.—Kituta, Lake Tanganyika, 24. 8. 04. From the soft region at the junction of the pelvic fins of a large *Polypterus congicus*. One specimen.

White Nile. From the fleshy region at the junction of the pair of pectoral fins of a *Polypterus senegalus*. Eighteen specimens, some of them incomplete, belonging to the collection of the British Museum.

Fashoda, White Nile. Eight further specimens (one incomplete) from the British Museum collection. The only particulars stated are:—"From *Polypterus birchir*, Fashoda."

It is interesting to note that this species of *Lernæocera* has been taken only on the Ganoid *Polypterus*, albeit on different species of that genus.

### 3. LERNÆOCERA TEMNOCEPHALA, sp. n. (Pl. I. figs. 8 & 9.)

*Description*.—(Adult female.) Cephalic arms four, of unequal size. The dorsal arms are long and stout, and fork distally in a Y-shaped manner, terminating in rounded lobes. The ventral arms are quite short, slender and simple, being bluntly pointed at their ends. The body is almost straight, unsegmented and cylindrical. The anterior third or less is moderately slender, the body dilating gradually behind. Pre-genital prominence

\* Cf. Jungersen, Mündeskrift for J. Steenstrup, xvi. Copenhagen, 1914, p. 6.

well marked, simple or slightly bilobed; terminal portion of body not upturned.

Total length of specimen, 10.0 mm.

From tip to tip of dorsal cephalic arms, 4.2 mm.

*Remarks.*—It is unfortunate that this species has to be described from a single specimen. Although no egg-sacs are present, it is almost certainly adult, and there seems no reasonable doubt that it represents a distinct form. This unique individual has unluckily been badly preserved, and as a result the body is nearly flattened towards its posterior end. It thus becomes impossible to determine the real diameter of this part of the body, and so to express the amount of dilatation which it has undergone. Similarly, an artificial twist in the body makes it virtually impossible to state the nature and degree of torsion. From the shape of the cephalic arms, this form may be placed not far from the oldest known European species, *L. cyprinacea* and *L. esocina*, from which it is nevertheless perfectly distinguishable. The dorsal cephalic arms in this specimen, as will be seen from fig. 9, are not quite bilaterally symmetrical, a condition of things which is met with in the genus from time to time.

*Occurrence.*—The specimen belongs to the collection of the British Museum. Particulars are given as follows:—"From *Barbus bynni*, bought in Old Cairo fish bazaar—caught in the Nile, Loat Coll., no. 26."

### 3. General Remarks.

It is clear that, whatever may be the case for marine fishes, the fishes of fresh water are relatively seldom the prey of parasitic Eucepoda under natural conditions. This is indicated by the paucity of material in the collections under review, for the specimens on which this paper is based come from eight individuals only. On the Third Tanganyika Expedition, of which I can speak personally, very large numbers of fish were examined, on only two of which were such parasites discovered. It is instructive to compare with this the occasions on which Argulidae—also external parasites—were obtained. They were taken 18 times in Lake Tanganyika, and in some cases on two or three individuals of the same species at the same time, while with lesser opportunities, they were found on three separate fish in the Victoria Nyanza, as against no record at all of parasitic Eucepoda. A study of the literature of the subject confirms our conclusion. There are, it is true, other families besides the Lerneidae which are represented in fresh water, but they do not constitute a very formidable assemblage, while the genus *Lernaeocera*, sole representative of its family, contains but a small number of species. Of these species it is certainly true to say that they are not very common, and in the majority of cases the remark is equally true of the other parasitic forms. When natural limits are transgressed, as they usually are in the stocking of ponds and rivers with fish, there not infrequently occur

serious epidemics due to vast numbers of parasites which have multiplied under conditions abnormally favourable to them.

It is worth while to mention that a few other specimens belonging to the British Museum have passed through my hands without receiving any notice in the general text. This is because they were too much damaged to permit of identification or description, but they can be referred to the genus *Lernæocera* almost with certainty, and as such are worthy of putting on record. They were all taken on Nile fish, and came from three separate individuals. One specimen was taken on a *Clarias lazera*, two more on another *Clarias* (? *lazera*), while two further specimens are labelled as follows:—"From *Barbus hyuni*—Damietta Nile, near Samannud. Loat Coll., no. 691."

As regards the distribution of these African species of *Lernæidæ*, it is to be noted that while one species has been found only in Tanganyika and another only in the Nile, the third form occurs in both. There is, then, no indication of that peculiar nature and superior richness of fauna which in so many cases characterises the lake. At the same time, we know as yet so extremely little of the distribution of these forms in Africa, that it would be out of place to lay much stress on the facts which have so far come to light. It is, indeed, a fact that the Tanganyikan species, *Lernæocera diceracephala*, is so far peculiar that it may be found necessary to establish a new genus for its reception, while the two Nile species are much more typical members of the genus *Lernæocera*. Further, if we deal with the parasitic Eucopépoda as a whole, including the Ergasilidæ, we still find that the fauna of Tanganyika is exceptional and unusually rich in diverse forms. Prof. Sars described\* a new genus—*Ergasiloides*—with three endemic species from Lake Tanganyika, and from Lake Nyasa only a single species of *Ergasilus* not further determined, but which is probably the same as that recorded by Mrázek from the Victoria Nyanza.

#### EXPLANATION OF THE PLATE.

(All figures by about 5.)

##### *Lernæocera diceracephala*.

- Fig. 1. Ventral view.
- 2. Lateral view.
- 3. View of cephalic arms from above.

##### *Lernæocera haplocephala*.

- Fig. 4. Ventral view.
- 5. Lateral view.
- 6. View of cephalic arms from above.
- 7. Lateral view of specimen infested with Vorticellids.

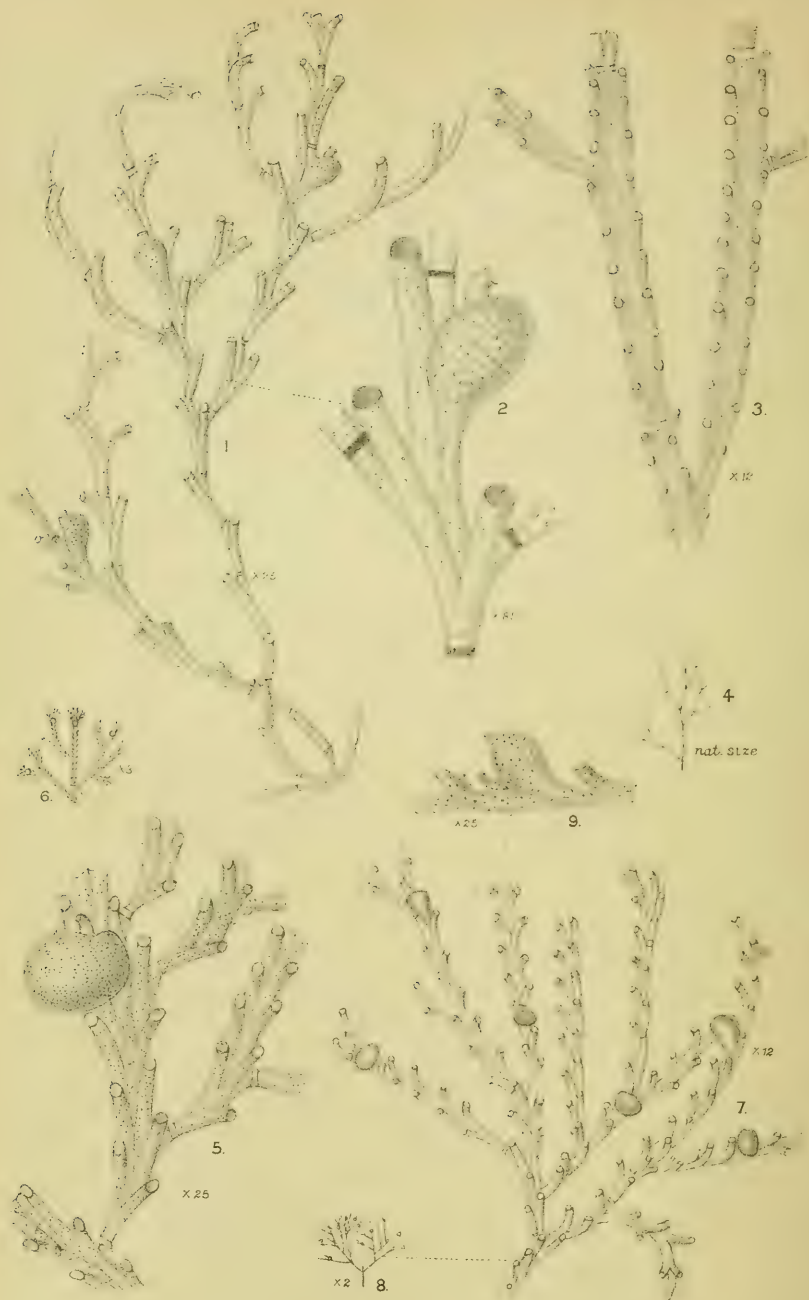
##### *Lernæocera temnocephala*.

- Fig. 8. Ventral view.
- 9. View of cephalic arms from above.

\* P. Z. S. 1909, p. 63.





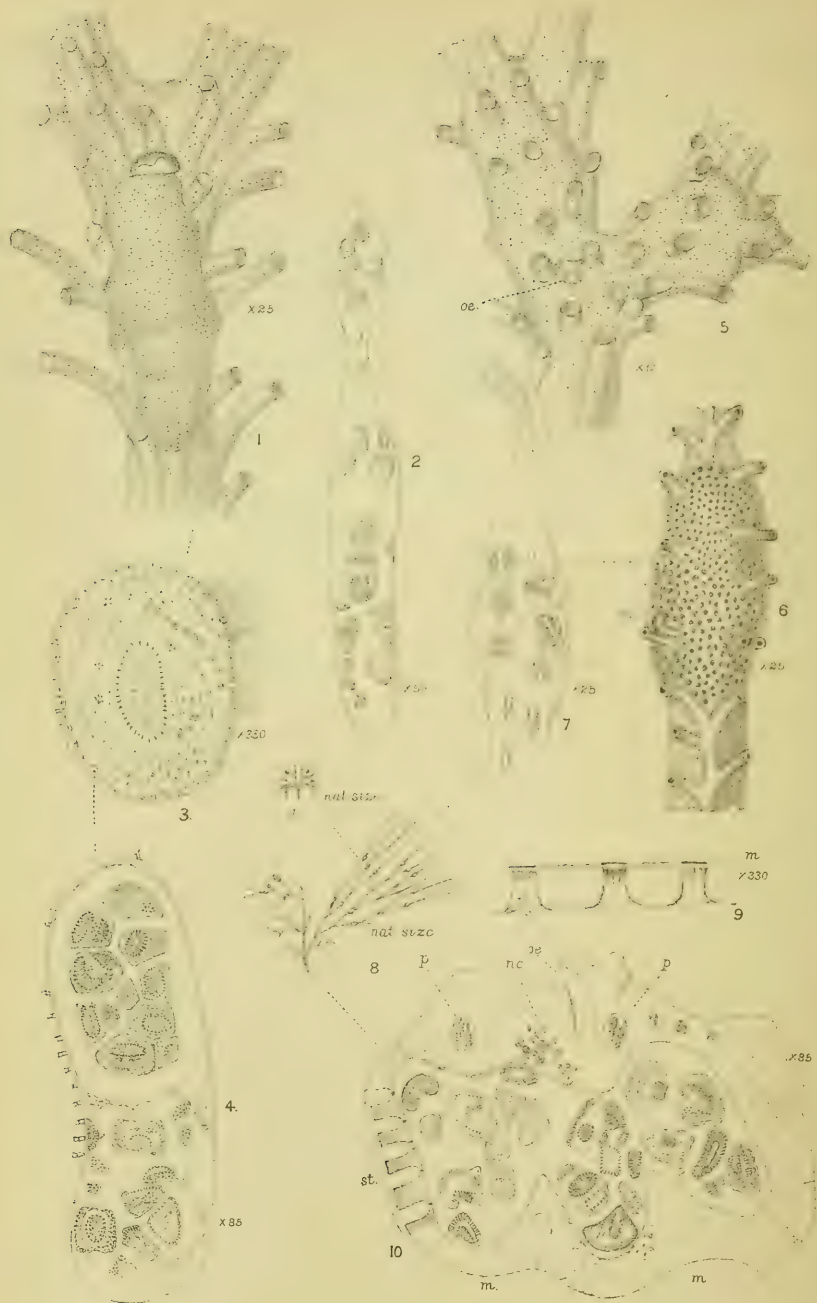


A. W. Waters, del.

Cambridge University Press.

BRYOZOA FROM ZANZIBAR.

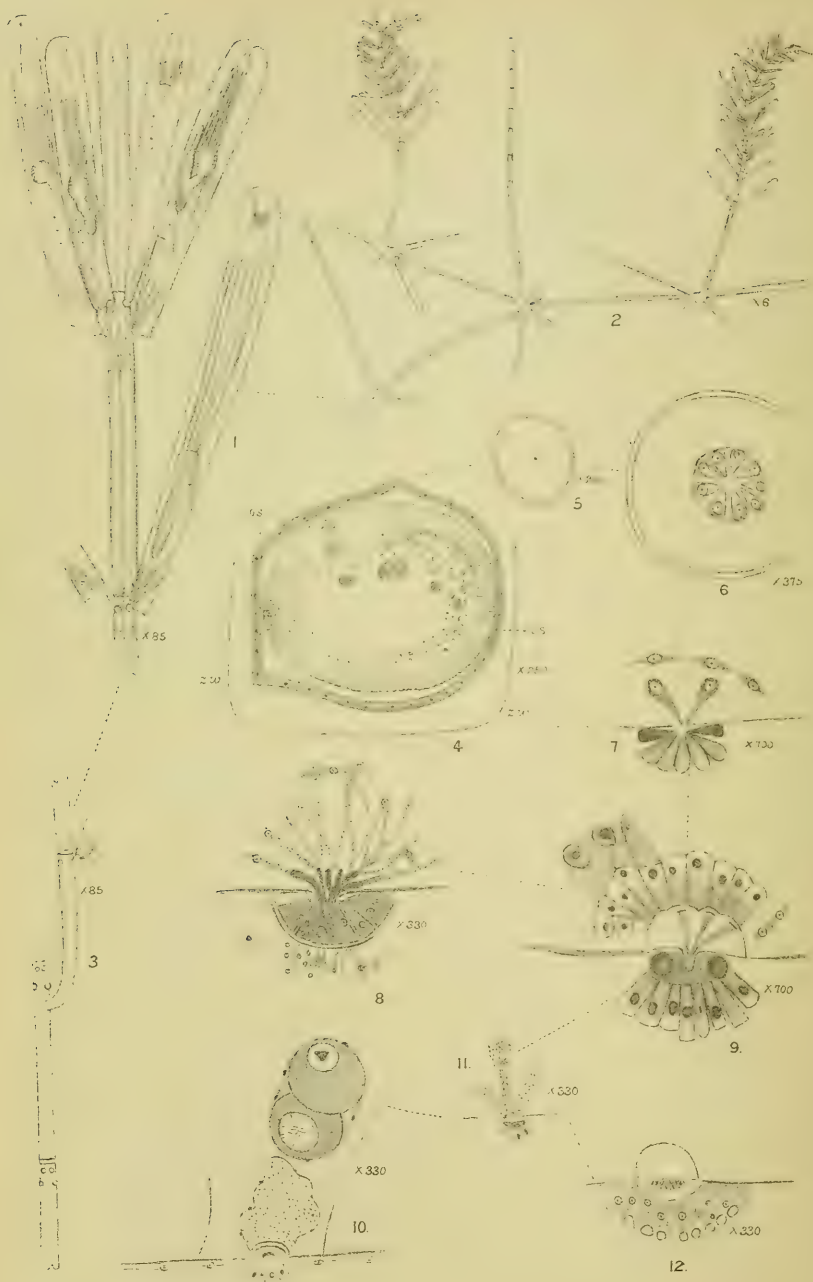




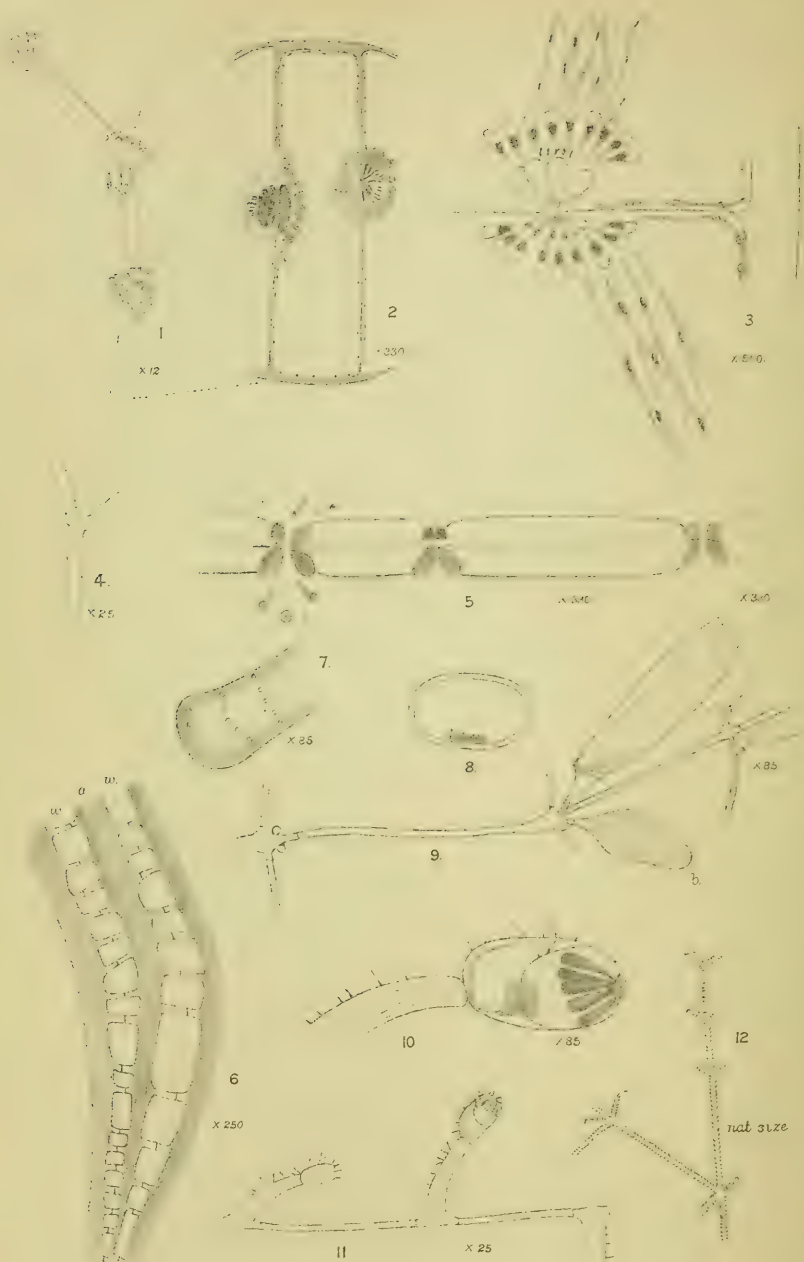
A.W. Waters, del.

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46. The Marine Fauna of British East Africa and Zanzibar, from Collections made by Cyril Crossland, M.A., B.Sc., F.Z.S., in the Years 1901-1902. Bryozoa—Cyclostomata, Ctenostomata, and Endoprocta. By ARTHUR WM. WATERS, F.L.S., F.G.S.\*

[Received May 19, 1914 : Read June 9, 1914.]

(Plates I.-IV.† & Text-figure 1.)

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The present paper continues the series on the collections made by Mr. Crossland in the tropics. The first was on *Tubucellaria*, published in the Journal of the Linnean Society, vol. xxx. 1907; then two parts in the 'Reports of the Sudanese Red Sea,' *ibid.* vol. xxxi. 1909, and vol. xxxi. 1910; and the Cheilostomata from British East Africa and Zanzibar in the 'Proceedings' of the Zoological Society, 1913.

The bibliographical references are pretty full in order that, so far as the tropics are concerned, they may be used as a continuation of Miss Jelly's Catalogue.

It should not be forgotten that all the specimens dealt with in this paper are from but a very slight depth (up to 10 faths.), so that but few Cyclostomata would be expected, since they mostly occur at considerable depths.

## Points of Special Interest.

The ovicells of *Entalophora*, and of *Idmonea radians* Lam., have been studied full of embryos, and the oeciostome has been cut through. In *Idmonea radians* the ovicells form lobes between each series of zoecia. The ovicells must be more used in classification, and the primary zoecia and the early stages must be examined.

The rosette-plates of Reichert in *Zoobotryon*, instead of having a number of pores round a central pore, as described, have a central pore and 8-9 cells round the pore. The mass of cells in the neighbourhood of the pore are dealt with.

27 species or varieties are mentioned in this communication,

\* Communicated by CYRIL CROSSLAND, M.A., B.Sc., F.Z.S.

† For explanation of the Plates see p. 857.

and 76 were described in the previous one, making 103 in all; of these 37 are known from the Atlantic, 22 are British, 31 Mediterranean, 37 are known from the Indian Ocean, 14 from S. Africa, and 51 from Australia.

*Table of Distribution.*

| Page |  | Atlantic. | British. | Mediterranean. | Red Sea. | Indian Ocean. | S. Africa. | Australia. | Fossil. |                         |
|------|--|-----------|----------|----------------|----------|---------------|------------|------------|---------|-------------------------|
| 837  | <i>Crisia denticulata</i> (Lamk.) ..         | +         | +        | +              | +        | ...           | +          | +          |         |                         |
| 838  | " <i>elongata</i> M.-Ed. ....                | ...       | ...      | ...            | ...      | ...           | +          |            |         |                         |
| 839  | " <i>sertularoides</i> (Aud. & Sav.) .....   | ...       | ...      | +              |          |               |            |            |         |                         |
| 839  | " <i>inflata</i> , sp. n. ....               |           |          |                |          |               |            |            |         |                         |
| 840  | " <i>circinata</i> , sp. n. ....             |           |          |                |          |               |            |            |         |                         |
| 840  | <i>Entalophora wasinensis</i> , nom. n. .... | +         |          |                |          |               |            |            |         |                         |
| 842  | <i>Filisparsa tubulosa</i> (Busk) ..         | + B       |          | +              | +        |               |            | +          | +       |                         |
| 843  | <i>Tercia irregularis</i> (Meneg.) ..        | +         | ...      | +              | ...      |               |            | +          | +       |                         |
| 844  | <i>Idmonea milneana</i> d'Orb. ....          | +         | +        | +              | ...      | + N           |            | +          | +       | Pacific.                |
| 844  | " <i>radians</i> (Lamk.) .....               | ...       | ...      |                |          |               |            | +          | +       |                         |
| 846  | " <i>interjuncta</i> MacG. ....              |           |          |                |          |               |            | +          |         |                         |
| 847  | <i>Anathia leudigera</i> (L.) .....          | +         | +        | +              | ...      | ...           | +          | +          |         |                         |
| 847  | " <i>semiconvoluta</i> (Lamx.) ..            | ...       | ...      | +              |          |               |            |            |         |                         |
| 848  | " <i>distans</i> Busk .....                  |           |          |                |          |               |            | +          |         |                         |
| 848  | " <i>vidorici</i> (Hell.) .....              | +         | ...      | +              | ...      | ...           | ...        |            |         | Roscoff.                |
| 849  | <i>Zoobotryon pellucidum</i> Ehr. ....       | +         | ...      | +              | +        | ...           | ...        | +          |         | Isle of Pines.          |
| 851  | <i>Boicetbankia pustulosa</i> (E. & S.) ..   | ...       | +        | +              |          |               |            |            |         |                         |
| 851  | <i>Mimosella bigeminata</i> , sp. n. ....    |           |          |                |          |               |            |            |         |                         |
| 852  | <i>Mimosella</i> sp. ....                    |           |          |                |          |               |            |            |         |                         |
| 852  | <i>Farrella atlantica</i> Busk .....         | +         | ...      | +              | ...      | +             |            |            |         |                         |
| 853  | <i>Falkeria uva</i> (L.) .....               | +         | +        | +              | +        | ...           | ...        | ...        |         | China Seas.             |
| 854  | <i>Cylindracium giganteum</i> (B.) ..        | +         | +        | +              | +        | +             | ...        | ...        |         | Queen Charlotte I.      |
| 854  | <i>Buskia nitens</i> Alder .....             |           | +        |                |          |               |            |            |         | Arctic, Q. Charlotte I. |
| 854  | <i>Pedicellina spinosa</i> (Rob.) ..         | ...       | ...      | +              |          | ...           | ...        |            |         | California.             |
| 855  | <i>Barentsia gracilis</i> (Sars) .....       | +         | +        | +              | +        | ...           |            | +          |         |                         |
| 855  | <i>Lorosoma singulare</i> Kef. ....          | +         | +        | +              |          |               |            |            |         |                         |
| 856  | <i>Lepralia poissonii</i> And. ....          | +         | ...      | ...            | ...      | +             |            | +          |         | Japan.                  |
| 856  | <i>Beania intermedia</i> Hincks. ....        | ...       | ...      | ...            | ...      | +             |            | +          |         |                         |

Levinson\* quotes Norman with regard to zoarial and zoöcial characters, who says: "Why also in all instances is the ultimate growth and form of the zoarium to be excluded from generic characters among certain families of the Cheilostomata, and at the same time to be recognised among the Cyclostomata and Ctenostomata, and even some other groups of Cheilostomata?"

Few characters have been available in the Cyclostomata, and those mostly zoarial ones, so that the classification of the group is still in a somewhat hopeless condition, whereas in the Cheilostomata very many characters are now used, and the classification is gradually becoming more natural. It is therefore to the more

\* Morph. and Syst. Studies on the Cheil. Bryozoa, p. 69 (1909).

highly differentiated Cheilostomata that we must at present look for guidance, rather than to the simpler Cyclostomata.

There are, however, some characters in the Cyclostomata, which when more used will help to show which forms are nearly related. Smitt showed that the ovicells furnished important characters, and on several occasions I have pointed out the importance of the ovicells, and of what I called the peristome of the ovicellular opening, saying in 1888\* that "the position and nature of the opening is most important, often more so than the shape of the ovicell." Harmer has confirmed what I said, and in several very valuable papers has gone into detail in some genera, and has named the passage by which the larva escapes the oöciostome, while the external orifice is the oöciopore, which terms are generally accepted, though unless new terms are absolutely necessary they are always to be regretted, as every branch of science is now overloaded with names. Also the size of the embryo, and of the zoöcial aperture, as well as the position and nature of the closures, give specific or generic characters.

The primary zoöcium and the growth of the younger part of the zoarium must receive much more attention, in fact up to the present in recent forms it has received hardly any: for example, in *Entalophora proboscidea*, *E. deflexa* Couch, and *Filisparsa tubulosa* there is a *Stomatopora*-like growth often spreading for a considerable distance over the supporting material, before the zoarium becomes erect, whereas in what has been considered to be *Entalophora rugosa* d'Orb., from Naples, there is a *Diastopora*-growth often covering a considerable piece of the stone or shell upon which it grows before the erect cylindrical zoarium is formed. It is elsewhere shown that other characters, namely the lamina and ovicells, prove that it belongs to the *Diastoporidae*.

To return to the more highly differentiated Cheilostomata: in various genera the zoarium may be either adnate, erect, uni- or bilaminate, or even articulated. For example, *Leprealia*, *Schizoporella*, Celleporidæ, all occur adnate, erect, uni- and bilaminate, while *Thalamoporella* may be unilaminate, bilaminate, adnate or erect and articulated; Cellaridæ in recent forms are usually articulate, except in the younger branches, but in fossils frequently there is no articulation. Now in none of these cases is there any material difference in the zoöcium according to the way in which the zoarium grows.

It is sometimes forgotten that all this only deals with the position of the zoöcia, or, as Levinsen would say, the "autozooids," and this has proved of quite secondary value in classification; but this does not mean that characters furnished by the other "zooids" such as avicularia, stalks, stolons, radicles etc., which also cause differences in the form of the zoarium, may not furnish valuable characters.

No doubt the Catenicellidæ are derived from unarticulated

\* "On some Ovicells of Cyclostomatous Bryozoa," Journ. Linn. Soc., Zool. vol. xx. p. 276.

forms, but evidently this is a long way back, so that now articulation is apparently a generic character; but there must have been a time when closely related forms were in some cases continuous, in others articulated, but now both zoarial and zoecial characters indicate a group of Catenicellidæ. In Cellariidæ and *Thalamoporella* the articulation is more recent, and should not be made a generic character.

Examining the Cyclostomata in the same way, we find to a certain extent parallels with the Cheilostomata: *Diastopora*, or perhaps we should say Diastoporidae, occurs adnate, but also bilaminate in such forms as *D. intricaria*, *Mesenteripora*; and some forms now placed with *Entalophora*, such as *E. regularis* MacG., belong to this family. Even the *D. obelia* division, which it has been proposed to raise to a genus *Diplopore*\*, has adnate forms, as well as the erect fossil *Diastopora brendolensis* Waters†, with tubules between the zoecia. A *Stomatopora*-like growth may become erect, and too much importance has been attached to whether a form is adnate or erect. There are adnate forms with Heteroporidan structure, and some bilaminate as *Favospira*.

The ovicells together with the œciostomes etc. are, as stated, going to assist us to trace relationship, but to what extent we cannot yet say, as our knowledge is in most families very incomplete, often fragmentary or absent. However, although only sufficient to show the direction in which work is wanted, it may be useful to put together what I have gathered from my own collection and from published accounts of recent forms.

In *Crisia*‡ the ovicells of most species are known, and they with the œciostomes furnish most useful characters in determination. In the species examined there are 8-9 tentacles.

In *Idmonea*, as at present understood, there are some important and rather puzzling differences in the ovicells. There is, FIRST, the *I. radians*, mentioned in this paper, also *I. atlantica* Forbes, *I. concava* Reuss, and *I. parasitica* Busk, in which the œciostome occurs on one side, usually on the second of the series enveloped by the ovicell, and by the first or second zoecium counting from the median line; the tube curves over and turns downwards (Pl. II. fig. 6, æ.). In these the ovicell spreads across the anterior surface.

SECOND. There may be merely an anterior inflation, usually near to a bifurcation, with a central œciostome, as *I. interjuncta* MacG.

THIRD. I have a fragment of an *Idmonea*, probably *australis*

\* This name cannot stand as it has already been used, see page 836.

† Quart. Journ. Geol. Soc. vol. xlviii, p. 155, pl. iii, fig. 1 (1892).

‡ Reuss (Foss. Polyparien des Wiener Tert. p. 99) described the Cyclostomatous ovicells as *Cœlophyma*, of which *C. glabrum* occurred on *Crisia hörnesi* (a *Crisia*), *Retepora disticha* (apparently *Idmonea*), and *R. cancellata* (do. *Idm.*); and *Cœlophyma striatum* on *Hornera hippolithus*.

Hagenow (Bry. Maest. p. 105) described *Cœlophyma lævis* on *Truncatula repens* and *T. truncata*; *C. constrictum* on *Idmonea tetrasticha* (this is not *Idmonea*, perhaps a worm *Truncatula*); and *C. granulatum* on *Idm. lichenoïdes*. Gregory does not quote Hagenow quite correctly.

MacG., in which the ovicell spreads over three or four series on one side only of the median line.

FOURTH. There is the very curious ovicell standing erect and embracing the zoecia of a series, which I described \* as occurring in *I. meneghini* Hell., but from an examination of more material I came to the conclusion that it was *I. triforis* Hell., and a co-type has confirmed this conclusion. As described, there was little to distinguish *I. meneghini* Hell. from *I. triforis* Hell. except size, so that without a fair amount of material they were not readily distinguished.

The zoecial aperture of *Idmonea* varies from 0.06–0.2 mm.

The so-called *I. irregularis* Meneghini has the ovicell dorsal, and must be removed to *Tervia*. It has 13 tentacles.

In *Tubulipora* there is an anterior ovicell spreading among many zoecia, with the oeciostome usually close up to a zoecial tube. Zoecial aperture 0.07–0.18 mm. Tentacles 11–12. The colony is, where attached, often provided with small projections or even long multitubular radicles, so that the attachment is but slight, whereas in *Stomatopora* it seems to be very close.

In *Filisparsa* there is an anterior ovicell. 14 tentacles.

In *Entalophora* few ovicells have been seen. In the *proboscidea* group they are not very large, and are near to several zoecial tubes without enclosing them. In *wasinensis*, the species described in this paper, the ovicell is very long and contains a considerable number of embryos. However, under *Entalophora* many species have been included which have a distinct lamina, and in these the ovicells found are of the *Diastopora* type, and suggest that they are erect cylindrical *Diastopora*. *Entalophora regularis* MacG., and what I called *E. rugosa* d'Orb., from the Mediterranean, must be removed on this account from *Entalophora*.

The zoecial aperture of *Entalophora* is 0.07–0.19 mm. The number of tentacles is 12–16.

*Diastopora*. The ovicell is vesicular, as an irregular or sub-globular elevation, often involving many zoecia, and sometimes situated tangentially to the colony. The ovicell may spread internally with many arms, as in *D. intricaria* Smitt†. So far as seen, the oeciostome of *Diastopora* is a small plain tube, usually directed proximally. The zoecial aperture is 0.06–0.11 mm.‡ The number of tentacles counted is 10–12. The ovicells of a very considerable number of fossil *Diastopora* have been figured, and the genus was abundant in the Jurassic and Cretaceous periods, and occurs as *Berenicea consimilis* Lonsdale, in the Silurian (see fig. in Bassler, "Bry.-Fauna of the Rochester Shale," p. 16, pl. v. figs. 1–5, 1906).

\* "Ovicells of Cyclost. Bryozoa," Journ. Linn. Soc., Zool. vol. xx. p. 278, pl. xiv. fig. 2 (1888).

† Waters, "Bryozoa from Franz Josef Land," Journ. Linn. Soc., Zool. vol. xxix. p. 173, pl. xix. fig. 12 (1901).

‡ In some fossils the orifice is larger, see Canu.

*Diastopora* with tubules has been called *Diplopore*, a name already used for a calcareous alga. MacGillivray made a genus *Diplopore*, but finding the name occupied changed it to *Diploporella*; the name *Diplopore* has also been given for two or three other things. The group, however, occurs incrusting and bilaminar. The family Diastoporidæ will probably be found to be more distinctly separated than any of the others.

*Hornera*. The ovicell is a large subglobular, dorsal or somewhat lateral chamber with large pits and a lateral œciostome. Tentacles, 9 in species examined. The "*Hornera eburnea*" Jull. & Calv. has a most curious anterior ovicell, but I do not see why it is placed with *Hornera*; also the *Hornera gravieri*\* Calv. seems to have a somewhat similar ovicell. Zoœcial aperture of *Hornera* 0.04–0.12 mm.

*Discotubigera* (*Defrancia*). Tangential ovicell with œciostome near the distal border. One specimen has the ovicell the whole way round the periphery. No doubt many species have been placed under *Lichenopora*.

*Stomatopora*. Although many *Stomatopore* have been figured and described, but very few ovicells have been seen, and Smitt† said no species were known with ovicells. In *S. divergens* Waters‡, the ovicell is a small round elevation on the anterior surface. In *S.* (?) sp. from Plymouth the ovicell is at the end of an erect branch as in *Supercyrtis*. In *S. major* Johns., the anterior ovicell has a small plain tube for the œciostome.

The *S. compacta* Norm. is *Diastopora*, and has the ovicells raised in between the openings of a small number of zoœcia, or is tangential, with the œciostome as in *Diastopora*. Norman's specimens examined are now in the British Museum.

*Lichenopora*. Ovicell central and spreading between the rays. œciostome erect, plain or funnel-shaped; or a plain horizontal tube low down near the edge of the ovicell. There may be many œciostomes, probably indicating several ovicells, just as a colony of *Diastopora* may have a number of ovicells. Smitt mentions eight œciostomes in *L. verrucaria*, and this must have been a fine specimen, as I have never seen more than six. The zoœcial apertures in all recent species measured are about the same size (from about 0.06–0.09 mm.).

*Defrancia lucernaria* Sars and *Domopora stellata* have the ovicells in between the rays.

*Fron dipora* has the ovicell across the anterior surface of a branch, not much raised, and the œciostome, about 0.12 mm. wide with the lower edge straight, also is but little raised, and is not attached to a group of zoœcia.

*Flosculipora* has the ovicell-wall uniting from neighbouring zoœcial bundles.

\* Calvet, "Bry. Cyclost. prov. des Camp. scient. accomp. p. S. A. S. le Prince de Monaco à bord de la Princesse-Alice," Bull. Inst. Ocean. No. 215, p. 7, fig. 5 (1911).

† Krit. Fort. 1866, p. 414.

‡ Expéd. Antarct. Belge, p. 89, pl. ix. fig. 6 (1904).

*Heteropora*. The ovicell is unknown in recent species, but Novak \* figures one in a Cretaceous fossil. It is sac-like with a small opening at one end. Tentacles 14 in *H. pelliculata* Waters.

*Supercytis* has the ovicell at the end of the erect colony spreading over the whole width. The *Supercytis tubigera* Busk, of the 'Challenger,' is not related to *Supercytis*, nor is it correctly described, as the series are not uniserial but biserial. It looks more like a *Tubulipora*.

*Crisulipora*. Oœciostome tube narrower than the zoœcial tube, without any terminal expansion. There are 10 tentacles.

*CRISIA DENTICULATA* (Lamarck). (Pl. IV. fig. 5.)

*Crisia denticulata* Waters, "Rep. Mar. Biol. of the Sudanese Red Sea, Bry. pt. ii. Cyclost. etc.," Journ. Linn. Soc., Zool. vol. xxxi. p. 232, pl. xxiv. figs. 1-3, pl. xxv. fig. 11 (1910); and add:—

Osburn, "Bry. of the Woods Hole Region," Bull. Bur. of Fisheries, vol. xxx. p. 216, pl. xviii. fig. 8 (1912); "Bry. from Labrador, etc.," Proc. Un. St. Nat. Mus. vol. xliii. p. 276 (1912); Guérin-Ganivet, "Bry. de la Région de Concarneau, etc.," Trav. Sc. du Lab. de Zool. et de Phys. Mar. de Concarneau, vol. iv. p. 19 (1912); "Mission Arctique: Bryozoaires," Soc. d'Océan. du Golfe de Gascogne, p. 39 (1913); Osburn, "Bry. of the Tortugas Islands, Florida," Pub. 182, Carnegie Inst. of Washington, p. 185 (1914).

We see that the connections from the stolons to the zoœcia, or through the septa of the stolon, in *Zoobotryon pellucidum* Ehr. (p. 849) and other Ctenostomata are much more elaborate than any description had indicated, a number of cells on each side meeting those on the other, and to these groups of cells reach the plasma network, which spreads through the stolon and the zoœcia. However, in *Crisia* and other Cyclostomata, I have not found a plasma network spreading all through the zoœcium, as we know it in Cheilostomata and Ctenostomata, but near the base below the cœcum there is a small number of threads. The polypide so nearly fills up the zoœcial tube, that there does not seem to be room for much network of plasma.

In *Crisia* and other Cyclostomata, the number of connecting pores is very considerable, being situated generally all along the surfaces, and, as a rule, the zoœcium at its proximal end is connected with the zoœcia on the two sides, in such a way that it seems impossible to speak of a new zoœcium having arisen from any one older zoœcium (Pl. IV. fig. 6). There are but few cells in contact with the pore, in this case apparently two on each side (Pl. IV. fig. 5).

*Loc. Add*: Atlantic, Cape Verde Islands. Wasin, Brit. E. Africa, 10 fath. (501, 516).

\* "Bry. der böhmischen Kreideformation," Denks. der Math.-Naturw. Cl. K. Akad. Wien, vol. xxxvii. pl. viii. figs. 30, 31 (1877).

CRISIA ELONGATA Milne-Edwards. (Pl. I. figs. 3, 4; Pl. IV. fig. 6.)

*Crisia elongata* Milne-Edwards, "Mém. sur les Crisies, les Hornères," Ann. des Sciences Nat. ser. 2, vol. ix. p. 10, pl. vii. fig. 2 (1838); ? Busk, Brit. Mus. Cat. Cyclost. p. 5, pl. iv. figs. 5, 6 (1875); ? Busk, Chall. Exp. Zool. vol. xvii. p. 5, pl. i. fig. 3 (1886).

The specimens from Wasin are without any doubt the species described by Milne-Edwards, even though he says "plus grêle" than *C. denticulata* Lamk., which is not the case. Busk, in his Museum Catalogue, speaks of the zoecia being much produced, whereas this is never the case in my specimens, nor does Milne-Edwards show it, or even Busk himself in his figures.

The lateral branch, of which there is one, and only one, to each joint starts from near the end of a joint, after about the 6th-10th zoecia on the one side. The last zoecial tube is continued free, as is the case to a certain extent with the last zoecium on the other side. The number of zoecia is uneven, and in some of the terminal nodes as many as 13 pairs of zoecia have been counted. There is the small mark below the oral aperture, as in *C. denticulata*, showing its relationship. The older chitinous joints are black, the younger ones are light. No ovicells are known.

The surface has numerous pores, and I do not understand Busk speaking of it as granular. The closure is slightly raised in the centre, and near this there are one or two pores.

The zoarium is about 0.3 mm. wide; the distance from zoecium to zoecium, on the same side, is about 0.25 mm., and the aperture of the zoecia is about 0.07 mm.

Since I wrote my Naples paper, I have been able to examine better specimens of what I took to be *C. elongata*, which correspond most nearly with *C. cribraria* Stimpson, as re-described by Osburn\*.

In the Naples specimens, the fresh internode arises after the 2nd, 3rd, or 4th zoecium of the one side, and another branch arises from after about the 6th zoecium on the other side; no ovicells were found, though some are forming at the very end of the branch, and the zoecia are about 0.45 mm. apart, which is about the same as in *C. ramosa* H., with which it is allied, but the chitinous joints are light. What I called var. *angustata*, I now consider is *C. ramosa* Harm.

The Algoa Bay specimen, so described in the British Museum Catalogue, is probably *elongata*, and in this specimen the fresh branches are always high in the internode. The 'Challenger' specimen named *elongata* I do not think is this species, and it has branches both high and low in the internodes, more as in *C. ramosa*. The specimens called *elongata* by Norman from Madeira are more like *C. ramosa*.

Loc. Red Sea? (*M.-Ed.*); Algoa Bay? Wasin, Brit. E. Africa, 10 fath. (501), collected by Crossland.

\* "Bryozoa of the Woods Hole Region," Bull. Bur. of Fisheries, vol. xxx. p. 215, pl. xviii. fig. 7 (1910).

*CRISIA SERTULAROIDES* (Audouin & Savigny)\*. (Pl. I. figs. 5, 6.)

*Proboscina sertularoides* Aud., "Descrip. de l'Égypte," Hist. nat. p. 236; Savigny, pl. vi. fig. 6.

*Crisia recurva* Heller, "Bry. des Adriat. Meeres," Verh. d. K.-K. zool.-bot. Gesellsch. Wien, vol. xvii. p. 118, pl. vi. figs. 3, 4 (1867).

Zoaria of rather straggling growth, apparently about 20 mm. high; internodes short, with 7-15 zoecia, though usually 7-9, with light joints, and the branches grow from above the first zoecium on that side, with sometimes another branch on the other side, near the distal end of the node. Branches not very wide (about 0.15 mm.); zoecia directed forwards with only a short part free, the distance from zoecium to zoecium is about 0.21 mm., the zoecial aperture is 0.06 mm.

The ovicells are very wide and large, irregular globular, placed to one side, and the oeciostome is funnel-shaped.

The growth is like that of *C. eburnea* L., but the branches arise higher up after the first or second zoecium, and in nodes where there is a branch the number of zoecia is uneven. It is also much like *C. acropora* Busk, though the denticle by the aperture occurs but very rarely; from *C. ramosa* Harm., it differs in having shorter internodes and in having the zoecia much nearer together. Although Heller's figures and description are unsatisfactory, it does not seem that there can be any doubt as to the identity of the species.

A specimen from Ras Osowamembe (504) has the zoecia less spread out, the joints black in the older parts, and the zoecia about 0.28 mm. apart; the ovicells are large and irregular over the whole width of the zoarium. The difference may only be local, and it seems advisable to consider it a variety.

*Loc.* Adriatic (*Heller*). Wasin, Brit. E. Africa, 10 fath. (500); Chuaka, Zanzibar, 3 fath. (506), collected by Crossland.

*CRISIA INFLATA*, sp. n. (Pl. I. figs. 1, 2.)

This is one of the most delicate species of *Crisia*, and is somewhat like *C. geniculata* M.-Ed., but there are two alternate zoecia in a joint, the new node rising from the end of the last. The nodes of *C. geniculata* are twice to three times as long, and the zoecial apertures of *geniculata* are about 0.075 mm., whereas in *inflata* they are only about 0.04-0.05 mm. The very light corneous tubes of the joint are, when examined with a high power, found to be marked with fine longitudinal lines.

The ovicell is suberect and is only an inflation of the zoecial tube, being the simplest ovicell known. From this character the specific name is chosen. The oeciostome is dorsal, so that it cannot be seen from the front, and is a small plain tube curved over, with a circular aperture 0.02-0.03 mm. The ovicell is not

\* [The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature (Proc. 7th Int. Cong., Boston 1907, p. 44 (1912)).—EDITOR.]

elongate like the ovicell of *geniculata*, as figured by Busk and Harmer, and also as a specimen in my collection. Harmer considers that *C. geniculata* and *C. cornuta* must be separated, chiefly on account of differences in the ovicell, and although the present species is also allied there seem to be sufficient reasons for its separation. The *C. crisidiodes* Ort. has 2-3 zoecia to each internode, with three-jointed setæ.

*Loc.* Wasini, Brit. E. Africa, 13 fath. (500), only one colony.

*CRISIA CIRCINATA*, sp. n. (Pl. I. figs. 7-9.)

The zoarium divides into two main branches, and on each of these the fresh branches are mostly given off from the one side, and in the lower part of the zoarium the fresh branch arises at about the second zoecium, while in the younger part the branches start from about the fourth. The joints are light. The distance from zoecium to zoecium is about 0.27 mm., and the round zoecial aperture is about 0.08 mm. There are fewer pores on the zoecia than in most *Crisiæ*, and the zoecia extend free for a considerable distance.

The ovicells, occurring just after a bifurcation, are large and erect, with the curved œciostome on the distal or dorsal surface of the ovicell, with the œciopore only 0.05 mm. diameter.

The ovicell of *Crisia* may appear to be central as in *C. ramosa* Harm., *C. fistulosa* Hell., etc., and is then long and pear-shaped, or it may appear to be at one side, and may be shorter, when we call it pomiform. There are others in which the ovicell is free, not being attached by its surface, and with the œciostome on its dorsal surface instead of being directed forwards. Free ovicells occur in *C. edwardsiana* d'Orb., *C. biciliata* MacG., *C. howensis* Maplestone.

I have felt much hesitation as to whether the form described is the *Crisia cuneata* Maplestone\*, and it also has many points of resemblance with *C. cylindrica* Busk, but a different ovicell is figured. The Museum specimens (528, 853) of *cylindrica* have no ovicells.

*Loc.* Ras Osowamembe, Zanzibar Channel, 10 fath., only one specimen (504); Prison Island, Zanzibar Channel, 8 fath. (505); Brit. E. Africa, 10 fath. (520): collected by Crossland.

*ENTALOPHORA WASINENSIS*, nom. nov. (Pl. II. figs. 1-4, 9; Text-fig. 1.)

*Entalophora deflexa* Smitt, "Floridan Bryozoa," pt. i. p. 11, pl. v. figs. 28-30 (1872).

As this does not seem to be the same as the small delicate British species known as *deflexa* Couch, I have given it another name.

The specimens from Zanzibar are buried in sponge, which has

\* "Lord Howe Island Polyzoa," Proc. Roy. Soc. Vict. vol. xvii. n. s., p. 390, pl. xxix. fig. 12 (1901).

grown over them. The zoarium is about 25 mm. high, dividing into many new branches at rather an acute angle. There are many zoöcia, with long tubes all round the zoarium, with the oral aperture 0.09 mm.-0.1 mm. There are 12 tentacles, and transverse sections show about 15-16 zoöcia.

The base of this species has not been seen, but *E. proboscidea* grows from a multiserial *Stomatopora*-like base, which often spreads for some distance before the erect growth commences.

*E. deflexa* also starts from a *Stomatopora* base which is

Text-figure 1.



*Entalophora wasincensis*.  $\times$  about 4.

principally uniserial, though in places it may be biserial. The zoöcia of this species, *E. elegans* Norm., and *E. deflexa* Couch, have the aperture about the same size and are allied; and as the zoarial growth of *E. elegans* Norman\* is similar, it is doubtful

\* "Polyzoa of Madeira," Journ. Linn. Soc., Zool. vol. xxx. p. 281, pl. xxxv. figs. 4, 5 (1909).

whether the greater projection of the zoœcial tubes may not depend on local conditions.

Only few ovicells have been found: one is small at the side just above a bifurcation, and has an œciostome with a narrow opening and a somewhat triangular plate in front of it. The other ovicells have the œciostomes like those in the first, and spread round several zoœcia without including any—that is, none pass through it. This structure was shown by Smitt (fig. 30).

Very few ovicells of recent *Entalophora* have been described. Busk says of *E. delicatula* B. "œcium tumid," but it has never been figured. In the 'Challenger' Report Busk, on pl. iv. fig. 1b, figures an irregular zoœcium as an "ovicell dilation," but from an examination of the specimen I think this is a mistake, as there is no sign of more numerous perforations, which we seem always to find on the ovicells of these groups of Cyclotomata.

In my collection there are ovicells on *E. regularis* MacG. and *E. intricaria* Busk\*, but these and some other species, among which what I considered was *E. rugosa* d'Orb., from Naples, will probably have to be removed from *Entalophora*, as sections show a distinct lamina, and the ovicells are wide with the zoœcial tubes passing through, reminding us of the ovicells of *Diastopora*, with which they are closely allied, but whether they must be called *Diastopora* or *Bidiastopora* need not now be considered. Among fossils also, no doubt many must be removed from *Entalophora* to *Diastoporidae*. D'Orbigny and others have also placed under *Entalophora* many species now removed to *Meliceritites*.

The ovicells of fossil *Entalophora* (*Spiropora*) *annulosa* Mich. are figured by Canu†, and are fairly similar to the ovicells of the present species. Canu does not figure the zoœcia spiral or regular, therefore why does he call it *Spiropora*?

*Loc.* Florida (*Smitt*). Wasin, Brit. E. Africa, 10 fath. (501) (507); Ras Osowamembe, Zanzibar Channel, 10 fath. (504): collected by Crossland.

#### FILISPARSA TUBULOSA (Busk).

*Hornera violacea* var. *tubulosa* Busk, Cat. Mar. Poly. pt. iii. p. 19, pl. xviii. fig. 4: for synonyms see Waters, "Austral. Bry.", Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 257 (1887); and "Rep. Mar. Biol. of Sudanese Red Sea, Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. p. 235, pl. xxv. figs. 16, 17 (1910); and add: Seguenza, Form. Terz. pp. 297, 372 (1879); De Stefani, "Jejo Montalto e

\* *E. intricaria* Busk has the rays or spines on the outside of the zoœcial tubes, which pass through the ovicells. The lamina is not seen in all stages, and in the section which I figured, Q. Journ. Geol. Soc. vol. xliii., pl. xviii. fig. 5, none is seen, though in other pieces it is quite distinct.

† "Études sur les ovicells des Bryoz. du Bathonien d'Occagnes," Bull. de la Soc. Géol. de France, 3<sup>me</sup> sér. vol. xxvi. p. 282, figs. 19, 20 (1898).

Capo Vat.," Mem. R. Accad. d. Lincei, vol. xviii. p. 208 (1882), Neviani, "Bri. Neog. delle Calabrie," Pal. Ital. vol. vi. p. 234 (1900).

As Busk made a mistake about numbering his figures, it is difficult to understand what he meant, but in spite of this it seems advisable to retain his name. Apparently the type *violacea* also should be *Filisparsa*, and in the Norman collection specimens so named, from Florö, have none of the appearance of *Hornera*, but look like *Filisparsa*, having anterior ovicells which are broken down. There is among these specimens one piece of *Hornera*, perhaps *lichenoides*, evidently misplaced.

The specimens from Wasin have the oral aperture about 0.15 mm., corresponding in this respect with specimens from Naples and Australia, and here also the closure of the zoöcial tube has a number of perforations similar in appearance to those of the zoöcia. There are 14 tentacles. The ovicell spreads over the front, and the oöciostome, directed somewhat backwards, is about the width of the zoöcial aperture, but in the longitudinal axis is only about 0.07 mm. There can scarcely be said to be a funnel, although there is an irregular expansion which frequently curves over.

The expansion and funnels of the oöciostomes of the Cyclostomata are often very variable, so that too much weight must not be attached to their measurements; also some ovicells may be found with and others without funnels.

There are some specimens from Zanzibar, apparently of this species, which in younger parts just touch the support at intervals, though there are no definite rows of dorsal projections as in *Tubulipora pulchra* MacG.; in the older parts there are strong calcareous radicles, sometimes formed of only one tube, but more frequently of two or three, which may divide at the end to form claspers. *Idmonea pedata* Norman has still larger radicles the width of the zoarium, often formed by five or six tubes.

A species from Naples, which I have considered to be the *Tubulipora incrassata* d'Orb. as more fully described and figured by Smitt, has zoöcia much about the same size, and standing up in the same way; but the zoarium spreads out fan-shaped, instead of being unattached for a considerable distance, and is continuous about the same width. The ovicell is situated as in *T. tubulosa*, with the oöciostome about the same size as the zoöcial tubes, sometimes ending off straight, at other times with a funnel.

*Loc.* Naples (*W.*); Victoria (*MacG.*); Holborn Island, Queensland, 20 fath.; North Atlantic (*B.*). Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

*Fossil.* Tertiary: Rhodes, Sicily, etc.

TERVIA IRREGULARIS (Meneghini). (Pl. IV. fig. 8.)

*Idmonea irregularis* Meneghini, "Polipi della fam. dei Tubul. finora osserv. nell' Adriatico," Nuovi Saggi del Accad. di Scienze,

Padova, vol. vi. p. 12 (1844). For synonyms see Miss Jelly's Catalogue and add:—

*Filisparsa irregularis* Waters, "Ovicells of Cyclost. Bry.," Journ. Linn. Soc., Zool. vol. xx. p. 279, pl. xiv. figs. 5, 6 (1888); Norman, "Poly. of Madeira," Journ. Linn. Soc., Zool. vol. xxx. p. 279, pl. xxxiv. figs. 1-3 (1909).

*Tervia folini* Calvet, "Rech. de la Camp. du 'Caudan,'" Ann. de l'Univ. de Lyon, p. 265, pl. vii. figs. 1-3 (1896).

*Tervia irregularis*, Jull. & Calv. "Bry. de l'Hirondelle," p. 114, & p. 157, pl. xiv. fig. 7 (1903).

The proximal part of the zoarium has the zoecia irregularly placed as in *Filisparsa*; then later, usually after the first branching, there are distinct series on each side, often with isolated zoecia in the median line. The very earliest part, namely the primary, is like that of *Stomatopora*, being about the same size as ordinary zoecia and but very slightly expanded at the proximal end, whereas in *Tubulipora* and many other Cyclostomata there is a large disk. This disk I have figured in *Tubulipora pulchra*, and it has also been figured by Barrois, Robertson and others.

Inside the zoecial tube, about the position where it becomes erect, there is on the proximal side a shallow comb-like process (Pl. IV. fig. 8). This is where the closure takes place. There are combs in some Membraniporidae, and spinous processes in many Cyclostomata, but I have not found a similar comb in any other Cyclostomata and it does not occur in *Filisparsa tubulosa*.

*Loc.* Adriatic; Naples, 40 fath.; Genoa; Bay of Biscay; Azores, 450 fath. (*J. & C.*); Madeira (*N.*); off Cape Blanco, West Africa, 235 met. (*J. & C.*); Australia. Wasin, Brit. E. Africa, 10 fath. (507), collected by Crossland.

#### IDMONEA MILNEANA d'Orbigny.

For synonyms and localities, see Waters, "Bry. from near Cape Horn," Journ. Linn. Soc., Zool. vol. xxix. p. 249 (1904).

From Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

#### IDMONEA RADIANs (Lamarck). (Pl. II. figs. 6, 7, 8, 10.)

For synonyms see Miss Jelly's Catalogue and add:—

Dollman, W. P., Journ. Roy. Micr. Soc. pl. viii. 1906, photograph only; Philipps, E. G., "Polyzoa collected by Dr. Willey," Willey's Zool. Results, pt. iv. p. 449 (1899); MacGillivray, "Monog. of the Tert. Polyzoa of Victoria," Trans. Roy. Soc. Vict. vol. iv. p. 121, pl. xvi. fig. 18 (1895).

Besides the more usual form with short branches (fig. 8a) there are from both localities specimens with long ones (fig. 8) having similar subparallel branches. MacGillivray has referred to a larger form, and Busk called it var. *erecta*. In the smaller

form as a rule there are two zoœcia to a series, though there may be three, especially near the growing ends, while the larger form has three zoœcia or occasionally four. A range of intermediate sizes have been met with.

The ovicells are anterior, near a bifurcation, or in other positions, even often half-way between two bifurcations; large pores or pits occur on the surface. The œciostome is on one side, most frequently by the first zoœcium of the second series involved (fig. 6), though sometimes it occurs by the third series, but never more than one œciostome has been seen on an ovicell, and the tubular œciostome turns over and downwards, resembling in position and form the œciostomes of *I. atlantica* F., *I. concava* Rss., and *I. parasitica* Busk.

The large lateral plates on the ovicell described by me\* as occurring in Torres Straits and Australian specimens, are not seen in those from Zanzibar, though from the localities previously mentioned they are very distinct, and are also seen in the 'Challenger' specimens from Tongatabu, and in the British Museum specimens from Cape Capricorn, where however they are elongate rather than round. There are no frontal ridges on the ovicell as described by MacGillivray. The series are about 0.26 mm. apart, which is much closer together than in any other species measured. *I. atlantica* F. is 0.6–1 mm.; *I. australis* MacG. 0.75 mm.; *I. concava* Reuss 0.5 mm.; *I. pedata* Norm. 0.45 mm.; *I. tumida* Sm. 0.7 mm. The zoœcial aperture is about 0.06 mm., whereas in *I. atlantica* it is 0.15 mm.; in *I. milneana* 0.16–0.2 mm. There are 8 tentacles.

The ovicell consists of several lobes, there being on both sides one between each two series of zoœcia, so that in a mature ovicell there are usually six such lobes. The embryos are small; the mature ones may be 0.1 mm. across or even a trifle larger, but the majority are smaller. There is not much difference from the embryos of *Entalophora wasinensis* nov., though a little larger, but they are smaller than those of *Diastopora intricaria* Sm., 0.12 mm.

Ostroumoff† says the larvæ of the Cyclostomata vary in size downwards from *Hornera* which is 0.48 mm., through *Tubulipora*, *Fron dipora*, *Lichenopora*, to *Crisia*, which last is only 0.07 mm. In sections I have found *Hornera lichenoides* 0.4 mm. and various species of *Crisia* from 0.07–0.1. The range in the Cheilostomata is somewhat similar, as *Diplodmoides* is 0.08, and *Systemopora* 0.37 mm.

This is no doubt *Crisina hochstetteriana* Stoliczka‡, but the

\* "Bry. from New South Wales" etc., Ann. Mag. Nat. Hist., ser. 5, vol. xx. p. 255, pl. vi. figs. 27, 28 (1887).

† "Zur Entwicklungsgeschichte der Cyclost. Seebryozoen," Mitt. Zool. Stat. zu Neapel, vol. vii. p. 180 (1887).

‡ "Foss. Bry. der Orakei Bay bei Auckland," Novara Expedition, p. 113, pl. xviii. fig. 3 (1864).

*I. hochstetteriana* of MacGillivray\* is clearly *Hornera*† *fissurata*, Busk.

The name *Idmonea*‡ is used in the sense it has been used for a long time, although recognising that in some cases it is difficult to find distinctions between *Idmonea* and *Tubulipora*, and that it is possible they may have to be merged.

But *Tubulipora* spreads out continuously, whereas *Idmonea* continues of the same width; also *Tubulipora* has a more or less central ovicell with a central œciostome, while *Idmonea* usually has the œciostome near to the series at one side. Perhaps further study of the primaries and early growth, as well as the ovicells, may establish the position, but for the present no harm is done by waiting until the whole of the group is better understood.

*Loc.* New Zealand, Wanganui, etc.; Tongatabu, 18 fath.; Honolulu, 20–40 fath.; Victoria; Port Jackson (*H.*), Adelaide (*A. W.*), Sydney; Port Stephens, 5–6 fath.; Green Point, 8 fath.; Darnley Island, Torres Straits, 10–30 fath.; Cape Capricorn, B.M. coll.; Lifu (*Ph.*); Port Elizabeth (in Miss Jelly's collection). Both the small and the var. *erecta* forms from Ras Osowamembe, Zanzibar Channel, 10 fath. (504), and Prison Island, Zanzibar Channel, 8 fath. (505), collected by Crossland.

*Fossil.* Orakei Bay, N. Z.; Mount Gambier, S. Aust.; Bairnsdale, Gippsland.

*IDMONEA INTERJUNCTA* MacGillivray. (Pl. II. fig. 5.)

*Idmonea interjuncta* MacG. Trans. Roy. Soc. Vict. vol. xxii. p. 137, 10 (sep.) (1886); Waters, "Austral. Bry.," Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 256, pl. vi. fig. 29 (1887).

*Idmonea pedleyi* Haswell, "Cyclos. Polyzoa of Port Jackson," Proc. Linn Soc. N. S. Wales, vol. iv. p. 351 (1880).

*Idmonea pulcherrima* Kirkpatrick, "Hyd. and Poly. from the China Sea," Ann. Mag. Nat. Hist. ser. 6, vol. v. p. 22, pl. iv. fig. 6 (1890).

The zoœcial aperture is about 0.12 mm., and the œciostome is the same size.

Some specimens from Ras Osowamembe have faint ridges on the dorsal surface, and by the side of these ridges are rows of pores, transverse to the zoarium. Lines of pores, though not as marked, are also found on *Idmonea milneana* d'Orb., a species in many respects similar, but *milneana* is a larger species having the zoœcial aperture larger.

*Loc.* Port Phillip Heads (*MacG.*); Green Point, Port Jackson, 8 fath. (*Waters*). Ras Osowamembe, Zanzibar Channel, 10 fath.

\* "Tert. Polyzoa of Victoria," Trans. Roy. Soc. Vict. vol. iv. p. 120, pl. xvi. figs. 12–16 (1895).

† See my re-description "On some Ovicells of Cycl. Bry.," Journ. Linn. Soc., Zool. vol. xx. p. 275, pl. xiv. figs. 1, 3, 4, 7 (1888).

‡ See Harmer, "Devel. of Tubulipora," Quart. Journ. Micr. Sc. vol. xli. n. s. p. 88 (1898).

(504); Prison Island, Zanzibar Channel, 8 fath. (505), collected by Crossland.

*AMATHIA LENDIGERA* (Linnæus). (Pl. IV. figs. 3, 4.)

For synonyms see Miss Jelly's Catalogue and add:—

*Amathia lendigera* (L.), MacGillivray, "On the Australian Species of *Amathia*," Proc. Roy. Soc. Vict. vol. vii. p. 135, pl. B. fig. 1 (1894); Calvet, "Bry. Ectoproctes," pl. viii. figs. 19, 20, pl. xiii. figs. 13, 21 (1900); "Bry. Mar. des Côtes de Corse," p. 46 (1902); "Bry. Mar. de la Région de Cette," p. 90 (1902); Jullien & Calvet, "Bry. de l'Hirondelle," p. 31 (1903); Guérin-Ganivet, "Bry. de la Rég. de Concarneau," Tr. Sc. du Lab. de Zool. et de Phys. Mar. de Concarneau, vol. iv. p. 23 (1912).

The stems of the specimens from Chuaka are about 0.07 mm. in diameter. This species differs from *A. vidovci* Hell. in not having the zoecia spiral, also in the branching being more or less at right angles to the main branch (fig. 4), whereas in most *Amathia* the branches divide equally in both directions. Hincks has figured the branching of *lendigera*.

Some sections of material from Swanage cut across the rosette-plate show the semicircle of cells, with nuclei at the end of the cell, directed to the pore; also the round mesenchym-cells with round nuclei are separated from the wall of the stolon, and are seen to pass over the mound of cells; up to this mound come the funicular threads with their elongate nuclei (fig. 3). The structure of the cells near the rosette is very similar to that described in *Zoobotryon* (see page 850).

*Loc.* British, French and Belgian coasts, Mediterranean, Adriatic; Corsica (40–60 met.) (*Calvet*); Azores (*J. & C.*); Western Port, Victoria (*MacG.*). Chuaka, Zanzibar shore (521, 523), collected by Crossland.

*AMATHIA SEMICONVOLUTA* (Lamouroux).

*Amathia semiconvoluta* Lamx. Encycl. Méth., Zoophytes, p. 44 (1824); Heller, "Bry. Adriat.," Verh. der K.K. zool.-bot. Ges. Wien, vol. xvii. p. 127, pl. v. figs. 1, 2 (1867); Calvet, Bry. Ectoproctes, pl. vii. figs. 8, 9, pl. viii. figs. 16, 18 (1900); "Bry. Mar. de la Région de Cette," Tr. Inst. de Zool. de l'Univ. de Montpellier, ser. 2, mém. 11, p. 89 (1902); Waters, Journ. Linn. Soc., Zool. vol. xxxi. pl. xxiv. fig. 6 (1910).

*Serialaria semiconvoluta* Lamk. Hist. Nat. d'Anim. sans vert., ed. ii. vol. ii. p. 171 (1836); d'Orbigny, Pal. Franç. vol. v. p. 595 (1850–52).

The yellowish thick chitin-stem is about 0.25 mm. diameter. Near the proximal end of each internode there is a clear oval spot, which is for the attachment of a radicle, yet although this mark for the attachment occurs in all internodes, radicles have only been seen in a very few cases. A similar mark for radicles occurs in *A. obliqua* MacG., and also in *A. brasiliensis* Busk, of

the 'Challenger,' which no doubt is really *A. semiconvoluta*, but the character has not been found in any other species examined.

*Loc.* Mediterranean; Naples (*A. W. W. coll.*); Adriatic (*Heller*). Wasin, Brit. E. Africa, 10 fath. (501), collected by Crossland.

#### AMATHIA DISTANS Busk.

*Amathia distans* Busk, Chall. Exp., Zool. vol. xvii. pt. 50. p. 33, pl. vii. fig. 1 (1886); MacGillivray, "On some S. Australian Polyzoa," Trans. Roy. Soc. S. Australia, vol. xii. p. 30 (1889); "On the Austral. Sp. of *Amathia*," Proc. Roy. Soc. Victoria, vol. vii. p. 134, pl. C. fig. 3 (1894); Waters, "Mar. Biol. of the Sudanese Red Sea, Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. p. 243, pl. xxiv. fig. 7 (1910).

The *A. distans* B., *A. tortuosa* B., *A. semiconvoluta* Lamx., and *A. vidovici* Hell. form an incomplete spiral round the stem, only occupying part of the internode. The stem of *A. distans* is thin, measuring 0.07 mm. diameter in most of the present specimens. The 'Challenger' specimens which I measured have the diameter about 0.1 mm. I seem to have measured some abnormal piece from Zanzibar which was stouter. From bifurcation to bifurcation is about 2 mm. long. There are 8 tentacles.

*Loc.* Off Bahia, 10-20 fath. (*B.*); South Australia (*MacG.*); New South Wales (*A. W. W. coll.*). Zanzibar town, shore, marked "pink Polyzoom" (527), collected by Crossland.

#### AMATHIA VIDOVICI (Heller). (Pl. IV. figs. 1, 2.)

*Valkeria vidovici* Heller, "Die Bry. des Adriat. Meeres," Verh. der K.K. zool.-bot. Ges. Wien, vol. xvii. p. 128, pl. v. figs. 3, 4 (1867).

*Vesicularia dichotoma* Verrill, "Invert. animals of Vineyard Sound," Rep. Comm. of Fish and Fisheries for 1871-2, p. 874.

*Amathia lendigera* Busk, Chall. Exp., Zool. vol. xvii. p. 33 (1886).

*Amathia dichotoma* Osburn (Verrill), "Bry. of the Woods Hole Region," Bull. Bur. of Fish. vol. xxx. p. 254, pl. xxix. figs. 81, 81 a (1912).

The zoecia at a bifurcation are in short biserial clusters, spirally arranged, encircling the stolon. There is sometimes a small cluster between a bifurcation as shown by Heller, whose figure was evidently from a dried specimen and is not entirely satisfactory.

The branches are about 0.2 mm. in diameter. There are 8 tentacles, which is the same as in *A. lendigera* L., *A. semiconvoluta* Lamx., *A. brongniartii* Kirkp., and *A. distans* B. The gizzard is about 0.05-0.06 mm. diameter.

The connecting cells on the two sides of the rosette-plates are fairly similar to those of *Zoobotryon pellucidum* Ehr., radiating on both sides from the pore, and the cells near this pore stain more darkly than the others (fig. 2).

*Loc.* Adriatic (*Heller*); Genoa (*Waters coll.*); Roscoff, sent to

me by Jullien as *A. semiconvoluta*; Bermuda, 30 fath. (*Chall.*); Great Egg Harbour, N. J.; Long Island Sound (*Verrill*); Vineyard Haven, Edgartown, Woods Hole, Nantucket (*Osburn*). Wasin, Brit. E. Africa, 10 fath. (500) (501), collected by Crossland.

ZOOBOTRYON PELLUCIDUM Ehrenberg. (Pl. III. figs. 4-12; Pl. IV. fig. 12.)

For synonyms see Waters, "Mar. Biol. of the Sudanese Red Sea, Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. p. 243, pl. iv. figs. 12, 15 (1910), and add:—Osburn, "Bry. of the Tortugas Islands, Florida," Pub. 182, Carnegie Inst. of Washington, p. 218 (1914).

The appearance of the specimens from Chuaka Bay, at first sight, suggest specific separation from *Z. pellucidum*, as on the whole length of the long internodes there are two distinct, wide series of zoecia closely crowded, but with vacant longitudinal spaces between the series. In the Naples specimens the existence of series of zoecia is obscured, as the zoecia in many cases seem to be scattered over the stem and the whole length is not usually covered; but an examination of the stolon of these Naples specimens after the zoecia have been removed, shows two groups of about four longitudinal rows of rosette-plates, so that the differences between the Naples and Zanzibar specimens are but slight, although the conditions of luxuriance are very different. Hincks's name of *biserialis* and MacGillivray's *bilateralis* would have been very suitable for this form. There are frequently more than three branches at the end of the internode, sometimes as many as six.

The zoecia are about 0.3 mm. long, and in the sections made the ova are usually single, or in some cases there are two in an ovium.

The embryo is surrounded by an ovicell sac, much the same as in *Adeonellæ*\* and in *Diplodidymia*\*, the growth of the embryo and of the sac going on simultaneously, and in many cases they are so close together that at first it is difficult to distinguish the sac from the embryo. In these cases the ovum must pass to the distal end under the operculum, from where it is developed.

On the other hand, in most of the Cheilostomata and in the Cyclostomata, the ovicell is formed before the embryo is ready for it. In the Cyclostomata the walls may be seen starting at various points† to ultimately unite to form the ovicell.

The rosette-plates were first described by Reichert‡ in this species, and it does not seem that anyone, except Smitt, had previously described anything of the kind, but what Smitt figured

\* Waters, "Bry. from Zanzibar," Proc. Zool. Soc. 1913, p. 529, pl. lxxiii. figs. 3 & 5, and p. 490, text-fig. 79.

† "On the Ovicells of some Lichenopora," Journ. Linn. Soc., Zool. vol. xx. pl. xv. fig. 6 (1888); "Mar. Biol. Sud. Red Sea, Bry.." Journ. Linn. Soc., Zool. vol. xxxi. pl. xxv. fig. 16 (1909).

‡ "Vergl. Anat. Untersuch. ü. *Zoobotryon pellucidus*, Ehr.," Abhand. k. Akad. der Wiss. Berlin, p. 276 (1869).

as a communication pore was evidently the entire plate, it not being realised that there were not large pores, but only minute perforations. Reichert described and figured the plate as with a central perforation with 8-10 pores round it\* (pl. iii. fig. 7), but this is not the case, as there is only one† perforation, and what Reichert took to be pores surrounding a central pore are really a circle of cells, on the older side of the rosette-plate, with a relatively large round nucleus and a thin prolongation. The disk is thinner than the surrounding walls, as figured by Reichert (*loc. cit.* pl. iii. fig. 7). Sections and preparations of *Zoobotryon* from Naples, the Soudan and Wasin, enable me to add slightly to our knowledge of this species.

By the rosette-plates of the zoœcia the cells just mentioned often stain very darkly, so that no structure can be seen, but in other cases the plate is seen with all these cells in a semicircle‡ (Pl. III. figs. 7, 8, 9, 12) pointing their thinner edge to the centre, or with them even raised to the one minute opening. Above, that is on the younger side of the rosette-plate, there are a number of cells, probably usually the same number as below, and these also have long thread-like projections which pass to the opening to touch the projections of the under circle of cells, that is as if eight fingers from below were raised to touch eight fingers from above. From both sets of cells spread other cells in a more or less radiating manner, and to these mounds of cells the funicular or plasma-threads reach, distinguishable from the others by their elongated nuclei. These plasma-cords spread to all the organs of the zoarium.

The layer of mesenchym-cells lining the zoœcial walls (Pl. III. fig. 10; Pl. IV. figs. 2, 3) spread to this mound of cells, and can be distinguished by the round cells and round nuclei from the funicular threads with their long cells and elongate nuclei. There is sometimes on one side a more or less semicircular cover over the circle of radiating cells, which it is difficult to understand, and they never occur in the early stages, and certainly they cannot be continuous all over or there would be no connection from the two sides.

An ovum is often seen pretty near to the rosette-plate, so that it must move up to the distal end to be enclosed in the ovisac. When there is an ovum, and usually in the older zoœcia, there is a considerable change in the funiculus near to the rosette-plate, as it has become granular (Pl. III. figs. 10, 11); so that from this appearance the condition of the zoœcium can be surmised.

Nitsche§ spoke of the accumulation of cells over the rosette-plate as a "Pfropf" (plug or stopper), and Reichert mentioned

\* This figure was copied by Hincks, Brit. Mar. Poly. p. ix, fig. 4.

† Joliet, Bry. des Côtes de France, p. 31, footnote, says that *Bowerbankia* has only one perforation. As I have previously stated, *Zoobotryon* and *Bowerbankia* should not be generically separated.

‡ This is the "joncturie" of Jullien, who describes a similar arrangement of cells to the joncturie of *Schizoporella malusii* Aud., 'Cap Horn,' p. 42.

§ "Beitr. z. Kennt. der Bryozoen," Zeit. f. wiss. Zool. vol. xxi. p. 9 (1871).

the thickening of the "Communale Bewegungsorgan" above and below the septa, whereas F. Müller had called it a ganglion, maintaining that there was a common nervous system through the colony; also Smitt\*, in *Bugula*, called them colonial nervous ganglia. We have seen that to these mounds of cells the network of plasma threads reaches, and this is what has been called the colonial nervous system and the colonial organ of movement, and it was figured by Müller, Reichert, and Nitsche as a stout, solid or tubular body, but instead there are a number of anastomosing and reticulate threads, though with very low powers it may look like a band: neither alive nor in stained sections is any such solid or tubular band seen. Nitsche's figures must be looked upon as diagrammatic, and Reichert's, as I have previously stated, as though he had *Zoobotryon* in a pathological condition, and it is to be regretted that Hincks copied his figures. Vigelius, Freese, and others have correctly understood these plasma threads.

It is strange that no histological work has been done on *Zoobotryon*, as it is eminently suitable for elucidating many interesting and important points of cell-structure, etc.

The name rosette-plate was given supposing that there was a rosette of pores, whereas there is really a rosette of cells.

*Loc. Add:* Florida (*Os.*); Chuaka Bay, Zanzibar, 2 fath. (509), collected by Crossland.

#### BOWERBANKIA PUSTULOSA (Ellis & Solander).

*Sertularia pustulosa* Ellis & Solander, "Nat. Hist. of many curious and uncommon Zoophytes," p. 54 (1786).

*Bowerbankia pustulosa* Hincks, Brit. Mar. Poly. p. 522, pl. lxxvi. figs. 1, 5 (1880); Calvet, "Bry. Ectoproctes," pl. vi. fig. 13, pl. vii. figs. 4-8, pl. viii. fig. 21, pl. x. fig. 13, pl. xi. figs. 18, 19, pl. xii. figs. 15-17, pl. xiii. figs. 11, 14 (1900).

The descriptions and determinations of *Bowerbankia* are so uncertain that there seems little object in giving a full list of synonyms. This species has been mistaken† for *Valkeria uva* L. and *B. imbricata* Adams.

*Loc.* British; Mediterranean; Chuaka, Zanzibar Channel, shore (523), collected by Crossland.

#### MIMOSELLA BIGEMINATA, sp. n. (Pl. III. figs. 1-3.)

The zoarium consists of unbranched stems (about 0.3 mm. diameter) rising from a spreading stolon (about 0.15 mm.). The first internode of the stem is long (say about 1.65 mm.) followed by one about 0.4 mm., and then the remaining ones are shorter, say 0.35 mm. There may be as many as 50 internodes in a stem. In the lower internodes there is only a pair of opposite zoecia close to the distal end, but after the second or third internode there is a second pair placed rather to the side and lower down but

\* Hafs-Bry. Utveck. Öfv. Stockh. Akad. xxii. pl. vi. fig. 7 (1865).

† See Waters, "Mar. Biol. of the Sudanese Red Sea, Bryozoa," Journ. Linn. Soc., Zool. vol. xxxi. pp. 249, 250 (1910).

close to the other pair. There are several cases where there has apparently been an injury, and a new branch grows from the side of the broken one, and then, although the original stem has had the double pairs of zoecia, yet the new growth may have more than two internodes with only a pair of zoecia, but subsequently there are two pairs to each, though special causes may occasion irregularities. The diaphragm at the base of a zoecium has one pore. Near the base of the zoecium there are strong muscles for moving the zoecium, and similar muscles occur in *M. gracilis* H., although Hincks said there were none. The new species differs from *M. gracilis* H. in the stems not branching, and in having four zoecia grouped at the distal end of the internode.

*Triticella armata* Verrill has the zoarial growth very similar to that of *Mimosella*, but, according to Osburn\*, it has a gizzard, and evidently does not belong to the present group.

The name *bigeminata* was suggested by Dr Harmer, who, when I told him that I had found and figured this *Mimosella*, thought that he had also found it in the 'Siboga' material. When he showed me his specimens, which are from better material than mine, the identity seemed to me quite clear, and, on seeing mine, Dr. Harmer agreed that this was the case, so that, with his permission, the name originally proposed has been changed.

*Loc.* Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

There is a small fragment of another *Mimosella* from Chuaka, which I hesitate to name as it is incomplete. Just below the diaphragm of the main stem there is a lateral stem on each side, and each of these has two or three single zoecia growing direct from the stem and directed distally, with this free unoccupied stem continuing beyond the zoecia. On the lateral stem there is a diaphragm before and after each zoecium. In one lateral stem there are two plates of attachment, as if there had been two pairs of zoecia, though on all the others the zoecia are uniserial. The zoecia are about 0.25 mm.-0.3 mm. long. The stem is about 0.02 mm. diam. The growth of this species somewhat reminds us of *Farrella atlantica* B., which, however, has the zoecia more or less stalked, whereas in this *Mimosella* the base of the zoecium is rounded like that of *Bowerbankia*. In *Valkeria uva* L. there is a diaphragm above and below the group of zoecia, whereas in *Mimosella gracilis* H., *F. atlantica*, and this species there is only the one diaphragm just beyond the branches.

#### FARRELLA ATLANTICA Busk. (Pl. IV. fig. 9.)

*Farrella atlantica* Busk, 'Challenger' Exped., Zool. vol. xvii. p. 37, pl. vii. fig. 3 (1886); Thornely, "Rep. Pearl-Oyster Fisheries of the Gulf of Manaar," p. 128 (1905); "Mar. Poly. Ind. Ocean," Trans. Linn. Soc. vol. xv. p. 157 (1912).

\* Osburn calls it *Hippuraria*, but I have shown that the genus was founded on a mistake, as the "stem" was a seaweed upon which it grew: see "Rep. Sudanese Bryz.," Journ. Linn. Soc., Zool. vol. xxxi. p. 241.

*Hippuraria verticillata* Hincks (*non* Heller), Ann. Mag. Nat. Hist. ser. 5, vol. xix. p. 311, pl. ix. fig. 8 (1887).

I have only found a small piece from the Red Sea, but it is evidently widely distributed, as I have it from Naples, the Red Sea, and Zanzibar.

The rhizome of the Zanzibar specimens is 0·01 mm. in diameter; the zoecia are 0·4 mm. long and 0·1 mm. wide, about the size given by Busk. At intervals on the stalk there is a pair of zoecia growing from an expanded part, and there is often from the same expansions a pair of radicles growing at right angles to the stalk; also frequently there are lateral branches near to the expansions, and these sometimes have pairs of zoecia near to the main branch.

A zoecium from which a polypide has disappeared usually assumes a swollen \* barrel-shape (Pl. IV. fig. 9, *b*), as the muscles which kept them in shape have now disappeared, and the same kind of thing occurs in many Ctenostomata.

I am unable to follow Hincks when he identifies his *Hippuraria verticillata* † with Heller's species; also I have shown that the genus *Hippuraria* was founded upon a mistake, and is only a synonym of *Triticella*. Although Hincks speaks of a group of cells at the joint, the figure shows a pair, and perhaps other nearly adjacent pairs have given the appearance of a group, so that, although I have scarcely any doubt as to Hincks's *verticillata* being a synonym of Busk's *atlantica*, there is just the possibility of this not being the case.

The peduncle is attached to the zoecium excentrically, and there is a muscle from the side of the wall to the projecting base of the zoecium by which it is moved as a whole.

There is a somewhat similar muscle in *Mimosella gracilis* Hincks. Joliet mentions this also in his *Valkeria nutans* ‡, and Hincks was apparently unaware of Joliet's later description when describing *H. verticillata*. Heller's figure of *Valkeria verticillata*, and Hincks's figure of *Valkeria uva* in the 'British Marine Polyzoa' are very similar.

*Loc.* Bahia, 10–20 fath. (*Chall.*); Naples (*A. W. W. coll.*); Adriatic; Suez; Ceylon (*Th.*); Indian Ocean (*Th.*); Amirante, 25 fath. (*Th.*); Providence, 50–78 fath. (*Th.*). Ras Osowamembe, Zanzibar Channel, 10 fath. (504); Wasin, Brit. E. Africa, 10 fath. (500), collected by Crossland.

#### VALKERIA UVA (Linnæus).

For synonyms see Waters, "Mar. Biol. of the Sudanese Red Sea, Cyclostomata, Ctenostomata, and Endoprocta," Journ. Linn. Soc., Zool. vol. xxxi. p. 250, pl. xxiv. fig. 13, pl. xxv. figs. 4, 12, 13 (1910); Osburn, "Biol. Survey of Woods Hole and

\* Journ. Linn. Soc., Zool. vol. xxxi. p. 239, pl. xxv. fig. 6.

† Ann. Mag. Nat. Hist. ser. 5, vol. xix. p. 311, pl. ix. fig. 8 (1887).

‡ "Études Anat. & Emb. sur le *Pyrosoma giganteum*," p. 106, pl. v. fig. 4 (1888).

Vicinity," Bull. Bureau of Fisheries, vol. xxxi. pt. 2, p. 606 (1911).

The specimens from Chuaka have groups of zoecia at distant intervals, and there are fully formed embryos in the zoecia.

*Loc.* See above and add: Vineyard Sound, 6-8 fath. etc. Chuaka, Zanzibar, 2 fath., on seaweed with *Stirparia dendrograpta* Waters (508); and Chuaka shore, on *Amathia lendigera* (521): collected by Crossland.

#### CYLINDRÆCIUM GIGANTEUM (Busk).

*Farrella gigantea* Busk, Quart. Journ. Micr. Sc. vol. iv. p. 93, pl. v. figs. 1, 2 (1856).

*Cylindroecium giganteum* Hincks, Brit. Mar. Poly. p. 535, pl. lxxvii. figs. 3, 4 (1880).

The largest zoecia from Chuaka are about 0.25 mm. long. There is no dilation at the base, and the contents of the wall are mostly calcareous, giving it a white appearance, so that at first I was inclined to call it var. *album*. When placed in acid it becomes transparent. The determination of *Cylindroecium* is always very unsatisfactory, and probably *C. giganteum* and *C. dilatatum* have not always been correctly distinguished.

The stolons branch in various directions.

*Loc.* British; Mediterranean; Red Sea; off Portugal; Ceylon; Cargados; Farquhar Reef (*Th.*); Queen Charlotte Island; Tortugas. Chuaka, Zanzibar, 2 fath. (508); Prison Island, Zanzibar, collected by Crossland.

#### BUSKIA NITENS Alder.

*Buskia nitens* Alder, Q. J. Micr. Sc. vol. v. p. 24, pl. xiii. figs. 1, 2 (1857); Hincks, Brit. Mar. Poly. p. 532, pl. lxxii. figs. 6, 7, woodcut, fig. 28 (1880); Ann. Mag. Nat. Hist. ser. 5, vol. xiii. p. (37); Levinsen, "Zool. Danica, Mosdyr," p. 83, pl. viii. figs. 12, 13 (1894).

From Ras Osowamembe, growing on the stalk of *Mimosella bigeminata*, nov. Levinsen says that there are 8 tentacles.

*Loc.* Arctic; Davis Strait, 100 fath.; British; Danish; Queen Charlotte Island (*H.*). Ras Osowamembe, Zanzibar Channel, 10 fath. (504), collected by Crossland.

#### PEDICELLINA SPINOSA (Robertson). (Pl. IV. figs. 10, 11.)

*Myosoma spinosa* Robertson, "Studies in Pacific Coast Entoprocta," Proc. Calif. Acad. of Sciences, ser. 3, vol. ii. p. 324, pl. xvi. figs. 1-12 (1900).

There are two specimens from Wasin, which well show most of the characters mentioned by Dr. Alice Robertson. The spines on both the stalk and calyx are stout and long, whereas those on *P. cernua* may be called almost hairs, and the spines are abundant on the one side and absent on the other, the obliquity of the tentacular region also occurs. The number of tentacles is about 14.

The stalk is broad, especially at the base, and is also wide where the calyx is attached, though not so wide as figured by Robertson in many of the figures, but she shows a distinct separation in fig. 4. In the stolon there is a septum pretty near to the stalk on each side of it, and there is a considerable space from stalk to stalk.

The preparation was stained and mounted for some other more transparent species, and it is not suitable for following any muscle from the stalk up the calyx, nor am I able to see anything suggesting it.

While unable to accept the genus *Myosoma* at present, of which I have been unable to make sections, it may turn out that it is advisable to retain the genus.

I now think that the *Pedicellina* from Naples with numerous stout recurved spines, to which I referred \*, is *P. hirsuta* Jull.

*Loc.* Tomales Bay, California, beach; Fort Point and San Pedro, California. Wasin, Brit. E. Africa, 10 fath., with *Coralina* etc. (500), collected by Crossland.

#### BARENTSIA GRACILIS (Sars).

For synonyms see Waters, "Rep. Mar. Biol. of the Sudanese Red Sea, pt. ii.," Journ. Linn. Soc., Zool. vol. xxxi. p. 251 (1910) and add:—

*Pedicellina gracilis* Föttinger, "Anat. des Pédicellines de la Côte d'Ostende," Arch. de Biol. vol. vii. p. 300, etc. (1886).

*Ascopodaria gracilis* Norman, "The Polyzoa of Madeira and neigh. Isl.," Journ. Linn. Soc., Zool. vol. xxx. p. 277 (1909).

Some of the stalks have the swelling in the middle, which have been found from many places, and in consequence of which the species *nodosa* was made. James Ritchie † has confirmed what I have said ‡ as to the genus *Gonopodaria* being superfluous.

*Loc.* Arctic; European coast, generally; Mediterranean; Red Sea; Madeira; Australasia. Ras Osowamembe, Zanzibar Channel, 10 fath. (504); Wasin, Brit. E. Africa, 10 fath. (500); Chuaka, Zanzibar, "from growth on elytron of Aphroditid"; Chuaka, Zanzibar, 2 fath. (508), (509), (519): collected by Crossland.

#### LOXOSOMA SINGULARE Keferstein.

*Loxosoma singulare* Kef. Zeit. wiss. Zool. vol. xii. p. 13, pl. xi. fig. 29 (1862); and add to Miss Jelly's Catalogue:—

*Loxosoma singulare* Jull. & Calvet, "Bry. prov. de l'Hirondelle," p. 28, pl. ii. fig. 5 (1903); Harmer, "Struct. and Devel. of *Loxosoma*," Q. J. Micr. Sc. 1885, p. 4.

There are a number of specimens growing on *Schizoporella*

\* "Mar. Biol. of the Sudanese Red Sea, pt. ii.," Journ. Linn. Soc., Zool. vol. xxxi. p. 252 (1910).

† "On an Entoproctan Polyzoan (*Barentsia benedeni*) new to the British Isles," Trans. Roy. Soc. Edin. vol. xlvii. p. 835 (1911).

‡ "Résultats du Voy. du S.Y. 'Belgica'—Bryozoa," p. 100 (1904); "Mar. Biol. Sud. Red Sea, pt. ii.," Journ. Linn. Soc., Zool. vol. xxxi. p. 252 (1910).

*nivea* B., and they are mostly, or at any rate exceeding frequently, attached to the operculum, indicating that the movement gained in this way is favourable to the *Loxosoma*.

*Loc.* Holland (*Kef.*); Shetland (*Hincks*); Naples (*Harmer, etc.*); Newfoundland (*J. & C.*). Prison Island, Zanzibar Channel, 8 fath. (505), collected by Crossland.

#### ADDENDUM.

Since I wrote about *Lagenipora socialis* H. in the description of the Cheilostomata from Zanzibar, pt. i. p. 510 (1913), I have examined the Norman Collection, recently sent to the British Museum, and there is a specimen from Hastings, sent by Mr. Hincks to Canon Norman as *Lagenipora socialis*, which has a pore at each corner of the ridge, as I described in the Guernsey specimens.

This entirely confirms the view that *Lagenipora socialis* is the type of the group which I have several times maintained was *Lagenipora*, but which Levinsen has called *Siniopelta*. By this specimen it is now definitely settled, and does not admit of further question, but the examination has brought out another interesting point. The *Celleporella* Norman belongs to the same genus, which, however, Norman at some time recognised, for he wrote on Hincks's co-type of *Lagenipora socialis*, "*Celleporella lepralioides*." However, under *C. lepralioides* he had two species, first the *L. socialis*, and then from Guernsey and from Hardanger Fiord specimens with several pores by the ridge of the ovicell, which are probably *L. lucida*, as well as *L. socialis*, both of which he had identified with *Celleporella lepralioides*. Of course, *Celleporella* has to disappear, as it was not recognisable from the description and figure.

I might have mentioned in the same paper, when speaking of *Actea*, p. 464, that what I call the bulging out of the zoöcial wall, for the ovum, before the ovicell has been formed, has been figured by Prouho in *Cylindrocium*\*.

In looking over seaweed for *Pedicellina* a few zoöcia of *Lepralia poissonii* Aud. have been met with from Wasin, Brit. E. Africa, 10 fathoms. The primary zoöcium has two or three more spines than Levinsen's figures. The species is known from the Atlantic, Australasia, Indian Ocean, and Japan (A. W. W. coll.), and is a common species in many localities. It also occurs fossil.

From Chuaka, 3 fathoms (523), a few zoöcia of *Beania intermedia* Hincks were found. There are no frontal spines, and near the proximal end there is a large plate for the attachment of the radicle, and at each side of this, near the border of the zoöcium either at the same level as the radicle or higher up, there is a

\* "Contrib. à l'hist. des Bryoz.," Arch. Zool. Expér. 2<sup>me</sup> ser. vol. x. pl. xxiv. figs. 14-17 (1892).

tubular projection, and from one of these a new zoecium may grow. Close up to the distal border on the dorsal surface there is on each side a small pore, which, however, is not seen in the Chatham Island specimens. Now I have previously remarked that most "*Beania* have six tubular connections, whereas this has only four," so that there is reasonable ground for considering these as vestigial, thus representing six connections. Two pores are found in this position in several Cheilostomata, as *Brettia*, *Catenicella*, etc., and we may, perhaps, now see the significance of these spots or disks.

The zoecia are about a third larger than those from the Chatham Islands and twice as large as those from New Zealand.

The *B. intermedia* has been found in New Zealand, Tasmania (*H.*), Chatham Islands (*W.*), Red Sea (*W.*), Australia, Indian Ocean.

## EXPLANATION OF THE PLATES.

### PLATE I.

- Fig. 1. *Crisia inflata*, sp. n.  $\times 25$ . From Wasin.  
 2. Do. do.  $\times 85$ . Showing ovicell.  
 3. *Crisia elongata* M.-Ed.  $\times 12$ . From Wasin.  
 4. Do. do. Natural size.  
 5. *Crisia sertularoides* Aud.  $\times 25$ . From Wasin.  
 6. Do. do.  $\times 3$ .  
 7. *Crisia circinata*, sp. n.  $\times 12$ . From Ras Osowamembe.  
 8. Do. do.  $\times$  about 2.  
 9. Do. do.  $\times 25$ . Ovicell seen from the side.

### PLATE II.

- Fig. 1. *Entalophora wasinensis*, nom. n.  $\times 25$ . Showing ovicell. From Wasin.  
 2. Do. do.  $\times 50$ . Section of ovicells containing embryos.  
 3. Do. do.  $\times 330$ . Embryo.  
 4. Do. do.  $\times 85$ . Section of ovicell containing embryos.  
 5. *Idmonea interjuncta* MacG.  $\times 12$ . Showing ovicell with oöciostome (*oe.*). From Ras Osowamembe.  
 6. *Idmonea radians*, var. *erecta* Busk.  $\times 25$ . Showing ovicells with oöciostome (*oe.*). From Ras Osowamembe.  
 7. Do. do. do.  $\times 25$ . Longitudinal section of the ovicell. Cut parallel to the anterior and dorsal surfaces.  
 8. Do. do. do. Natural size, showing the position of the ovicells  
 Fig. a. *Idmonea radians* Lam. typica. Natural size.  
 9. *Entalophora wasinensis*, nom. n.  $\times 330$ . Section of the surface pore-tubes; (*m.*) exterior membrane.  
 10. *Idmonea radians*, var. *erecta* Busk.  $\times 85$ . Section from the anterior to the dorsal surface of the zoarium, showing the lobes of the ovicell and the oöciostome (*oe.*) as well as the polypides (*p.*). The structure of the wall of the ovicell is seen at the left (*st.*) with one or two rosette-plates at the base of the broad pore-tube. There is an outer membrane (*m.*).

### PLATE III.

- Fig. 1. *Mimosella bigeminata*, sp. n.  $\times 85$ . Showing the lower internode with only a pair of zoecia, while the upper one has two pairs. From Ras Osowamembe.  
 2. Do. do.  $\times 6$ . Showing several stems growing from the creeping stolon.  
 3. Do. do.  $\times 85$ . Showing a new stem growing from the side of an old one after mutilation.

- Fig. 4. *Zoobotryon pellucidum* Ehr.  $\times 250$ . Embryo in ovisac (os.). Zoecial wall (zw.). This shows the embryo hollow, which is very generally the case in embryos of this type.
- |     |     |     |                |  |
|-----|-----|-----|----------------|--|
| 5.  | Do. | do. | $\times 200$ . | Disk of rosette-plate showing one small pore in the centre.  |
| 6.  | Do. | do. | $\times 375$ . | Disk of rosette-plate with a circle of cells round the pore.   |
| 7.  | Do. | do. | $\times 700$ . | Section across the rosette-plate showing cells directed to the small opening; with mesenchym cells above. Only two of the radiating cells above the rosette-plate are shown, as the others are only seen in a different focus, but there will be 8 or 9. |
| 8.  | Do. | do. | $\times 330$ . | Section across the rosette-plate in a septum of a main stolon. Showing a spreading plasma with cells scattered about. From the Sudan.  |
| 9.  | Do. | do. | $\times 700$ . | Section across the rosette-plate from the stolon to the zoecium.   |
| 10. | Do. | do. | $\times 330$ . | Section across the rosette-plate; above it there is an irregular granular mass. This is in a zoecium in which there is an ovarium, and degeneration has taken place.   |
| 11. | Do. | do. | $\times 330$ . | Section across the rosette-plate from a stolon to a zoecium, showing irregular granular masses in a zoecium that is degenerating.  |
| 12. | Do. | do. | $\times 330$ . | Section across the rosette-plate from a stolon to a zoecium.   |

In all cases the figures show the older part below the rosette-plate, and the younger above.

#### PLATE IV.

- Fig. 1. *Amathia vidovici* Hell.  $\times 12$ . From Wasin.
- |     |                                       |     |                |  |
|-----|---------------------------------------|-----|----------------|--|
| 2.  | Do.                                   | do. | $\times 330$ . | Section where a new branch is formed on each side, showing the cells round the two rosette-plates. The plug of cells on the left are not cut close to the opening of the rosette-plate, and the two inner plugs have become somewhat granular. |
| 3.  | <i>Amathia lendigera</i> L.           |     | $\times 500$ . | Section through the rosette-plate of the septum of the stolon. Examined with $1/12$ immersion. From Swanage.   |
| 4.  | Do.                                   | do. | $\times 25$ .  | Showing the branch at a bifurcation arising almost at right angles to the main stem.   |
| 5.  | <i>Crisia denticulata</i> Lamk.       |     | $\times 330$ . | Section through the inner wall of a zoecium, showing the connections from zoecium to zoecium (c.). From Swanage.   |
| 6.  | <i>Crisia elongata</i> M.-Ed.         |     | $\times 250$ . | Proximal end of zoecium—(a.) showing connection to the two neighbouring zoecia, through numerous tubes in which there is a septum in the middle, zoecial walls (w.). From Wasin.   |
| 7.  | <i>Stomatopora</i> .                  |     |                | Primary zoecium. $\times 85$ .   |
| 8.  | <i>Tervia irregularis</i> Meneghini.  |     |                | Comb-like process in the zoecial tube near where it becomes erect. From Naples.  |
| 9.  | <i>Farrella atlantica</i> Busk.       |     | $\times 85$ .  | From Ras Osowamembe.   |
| 10. | <i>Pedicellina spinosa</i> Robertson. |     | $\times 85$ .  | From Wasin.  |
| 11. | Do.                                   | do. | $\times 25$ .  |  |
| 12. | <i>Zoobotryon pellucidum</i> Ehr.     |     |                | Natural size. From Chuaka Bay.   |

47. Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. By FRANK E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S., Prosector to the Society.

[Received May 5, 1914: Read June 9, 1914.]

(Text-figures 1-11.)

XIV. ON A NEW SPECIES OF *RHABDOMETRA*, AND ON THE PARUTERINE ORGAN IN *OTIDITÆNIA*.

INDEX.

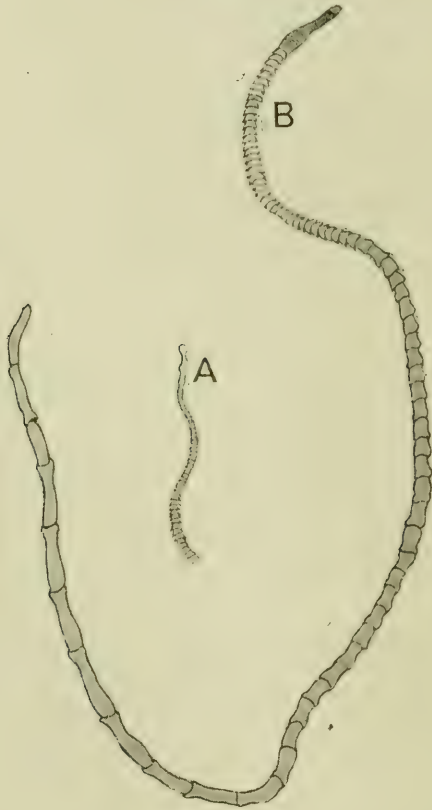
|   | Page |
|---|------|
| Description of <i>Rhabdometra cylindrica</i> , sp. n. ....      | 859  |
| Paruterine Organ of <i>Otiditænia eupodotidis</i> Beddard ..... | 879  |

I have recently obtained a considerable number of examples of a Tapeworm from an African Partridge, *Caccabis melanocephala*, which I refer, temporarily at least, to the genus *Rhabdometra*, though a closer comparison of this worm with the known species of *Rhabdometra* may ultimately necessitate its separation from that genus. The worm occurred in the Partridge associated with several other species, and I found always a relationship in numbers between the different forms which inhabited that bird. I examined altogether five specimens of the *Caccabis* in three of which were found examples of the *Rhabdometra*. In two examples there were a large number of specimens of the *Rhabdometra*, and in the other example only two specimens. The birds, which were infested by many specimens of *Rhabdometra*, contained also apparently only one representative of other species of Tapeworms. In the one case it was a *Davainea* and in the other a *Cotugnia* (?) In the bird where there were only two *Rhabdometra* there were many *Davaineæ*.

The general appearance of this worm is indicated in text-fig. 1. It is long and slender; when alive the longest examples were fully six inches or so in length. In spirit the dimensions are somewhat lessened. This great length is accompanied by only a small diameter; the width varies from something under one millimetre, to a little over a millimetre. The greatest diameter was anteriorly in the body but some way behind the head; here the proglottids are broader than long. The scolex as a rule appears to be a little less in diameter than the ensuing region of the strobila. But occasionally, as depicted in text-fig. 1 A, the scolex stands out as a globular body followed by a constriction. In an examination of the living worms I noted one example in which there was no neck, an unsegmented region following upon the scolex; and I have one mounted preparation (represented in text-fig. 2), where the same feature is to be seen. But I have no note as to whether these examples were the same. As a general

rule there is no neck and segmentation begins immediately after the scolex. The scolex is rather small and the suckers are large in proportion, occupying most of the area of the scolex. There was no trace of any hooks whether related to a rostellum or upon the suckers. I ascertained this by transverse and longitudinal sections as well as by the examination of entire scolices mounted

Text-figure 1.



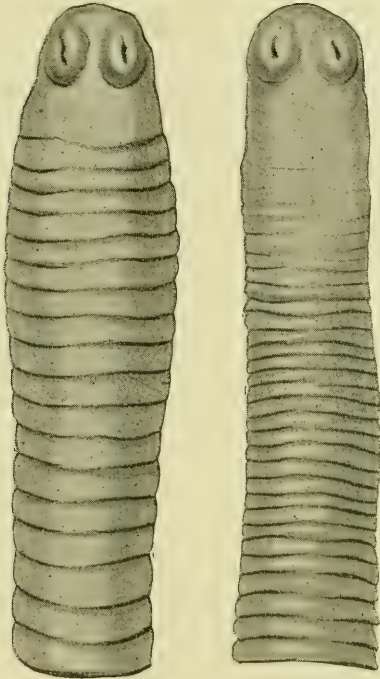
A. Head-end of an example of *Rhabdometra cylindrica*.

B. Another and complete specimen of the same species.

in glycerine. It is very important to be positive upon this point, since the difference between the genera *Rhabdometra* and *Paruterina* is practically entirely to be found in the absence in one and the presence in the other of a rostellum armed with hooks. The strobila consists of proglottids, which are at first narrow and then

rather wider. The end of the body, often more than one half of the entire worm, is made up of very long proglottids which I found to measure as much as five and six millimetres in length. They are thus quite as much as or even more than six times as long as they are broad. There is no one of the known species of *Rhabdometra* in which the ripe proglottids are so long as in the species described in the present communication. It may be,

Text-figure 2.



Anterior end of two specimens of *Rhabdometra cylindrica*.

The right-hand figure shows the existence of an unsegmented neck rare in the species.

however, that the individuals of the various species examined by my predecessors were not so fully mature as those which I have myself been able to study. The greatest length of the hinder proglottids is to be found, as it would appear, in *Rhabdometra nigropunctata*, where, according to Crety\*, they are three times the length of their diameter. That is considerably less than I have

\* Boll. Mus. Torino, v. 1890, No. 88. It should also be noted that this species, which measures 140 mm., is nearest in length to mine.

met with. The anterior relatively broader segments are rather flattened in transverse section. The posterior proglottids are sometimes quite cylindrical in form, being circular in section. Or they may be more oval, though still of great depth dorso-ventrally.

In transverse sections such as are represented in text-fig. 6, the cortical layer is seen to be fully as thick as, and occasionally even a shade thicker than, the medulla. The distribution of the longitudinal muscular layer seems to be very much as it has been described by Fuhrmann\* for the allied species *Rh. numida*. Next to the transverse muscles there is a layer of rather widely spaced bundles with not more and sometimes less than 5 or 6 fibres in each. Between these and the subcuticular layer are numerous scattered longitudinal fibres implanted singly. The transverse fibres form a rather thick layer, and in the anterior region of the proglottid, where the medulla is free from the testes etc., and in the area partially occupied by the paruterine organ, the transverse fibres encroach further upon the medullary parenchyma, which is largely pervaded by them. Dorso-ventral fibres are also abundant in the medullary layer and, as mentioned later, are not at first displaced by the paruterine organ.

The *water-vascular system* consists of the two usual longitudinal vessels, of which the very much larger ventral vessels are united by an equally wide transverse vessel at the posterior end of each proglottid. The opening of the longitudinal vessel into the transverse vessel is guarded by a valve which prevents the reflux of fluid into the longitudinal vessel anteriorly. I could find no other branches of the ventral vessel to form a network such as appears to exist according to Ransom in *Rhabdometra nullicollis*. The dorsal vessel lies above the ventral and often rather to the inside; it is very small but has relatively thick walls. The genital ducts pass between the two vessels and below the nerve-cord, which is displaced towards the dorsal side from its usual position, where the ducts pass beneath it. It will be noted that in the relations of the nerve-cord to the genital ducts the present species differs from both *Rh. nullicollis* and *Rh. similis*, where the genital ducts pass dorsal of the nerve-cord.

The *testes* are numerous, and often very closely pressed together. They lie on all sides of the ovary and vitelline gland, being found laterally and posteriorly as well as anteriorly in the segment. In the most mature segments the testes are only plainly to be recognised posteriorly in the segment lying behind the uterus. Laterally the testes in the ripe but not fully mature proglottids extend as far as the water-vessels on each side. Anteriorly the boundary of the area occupied by the testes is some way short of the anterior margin of the proglottid. In transverse sections of proglottids where the uterus is nearly fully developed, the testes are seen to lie dorsally of the uterus, which latter organ

\* Res. Swed. Zool. Exp. Egypt, pt. iii. No. 27, 1909.

occupies the whole ventral surface of the proglottid. The extension of the testes anteriorly in the segment seems to be prevented by the paruterine organ, which in those proglottids where the testes are fully ripe extends backwards for about half the length of the proglottid and takes up the greater part of the available space. It is important to insist upon the fact that the testes surround the female gonads, since this does not appear to be the case with other species of this genus *Rhabdometra* as figured by Ransom. The genus is, in fact, partly defined by the existence of the testes only behind and at the sides of the female organs. The testes are only two deep in a given segment.

The *cirrus-sac* is long and slender, longer than that of the species figured by Ransom, but considerably shorter than the cirrus-sac of *Rh. namida* of Fuhrmann, which reaches to the middle of the segment. In segments where the gonads are ripe but in which there is as yet no uterus, the cirrus-sac very nearly reaches the middle of the segment; but in older and wider segments it only just crosses the ventral water-vessel. Its course is obliquely forward from the point of opening on to the exterior, which is rather behind the middle line of the proglottid. There can hardly be said to be a genital cloaca: a funnel-shaped depression of the body, into the bottom of which the genital ducts open (the male duct anterior to the female), not showing the characters of a distinct chamber such as that of, for example, *Eugonodæum*. In horizontal sections the cirrus-sac often has a serpentiform outline, being like an elongated S. Occasionally it is slightly dilated at the internal end, but the cirrus-sac of this *Rhabdometra* never has the bottle-like form of that of many other tapeworms. In consequence of its length and slenderness the cirrus is not much coiled within it, lying mostly straight or rather in an undulating line. I could detect no spines upon the cirrus when protruded. I did not observe any autocopulation. The walls of the cirrus-sac are thick and very muscular. The internal coat is of circularly running fibres, the outer layer fibres run longitudinally. From the internal end of the cirrus a retractor muscle runs for some way into the medullary tissue. This character is also found in other species of the genus *Rhabdometra*. The vas deferens forms a large coil which is situated posteriorly to the paruterine organ, and extends backward in the proglottid to as far as the receptaculum seminis. At about this point the efferent tubules from the testes meet it. There is no vesicula seminalis.

The *ovary* lies at about the middle of the segment. It is in front of and larger than the *vitelline gland*:

The *vagina* is long and thick-walled, and outside of the muscular walls is a layer of stalked glands which are deeply stained by hæmatoxylin. The course of the vagina is directed parallel to and slightly away from the cirrus-sac to begin with; it then curves more backwards to open into the receptaculum seminis. Its course is apt to be rather undulating. Ransom has figured a sudden change in the character of the vagina in the species

described by himself, occurring at some distance from the opening into the receptaculum. It here becomes much narrower. Nothing of the kind occurs in *Rhabdometra cylindrica*, except, perhaps, just at the orifice; and, moreover, the coating of gland-cells extends over the entire vagina, up to the receptaculum. The latter is large and spherical to rather oval in form; it lies obliquely to the longitudinal axis of the body towards the pore side.

### § *The Paruterine Organ.*

This structure is of such importance in the group of tapeworms of which the present species is a member, that it needs a detailed treatment for comparative purposes. In the living worm the paruterine organ is exceedingly conspicuous as a rod-like body at the anterior end of the proglottid, often of a brilliant white, thus contrasting with the more pellucid tissues of the outer layers of the worm. This aspect led me at first to regard the paruterine organ as the uterus crammed with eggs, which might be expected to show a bright white owing to the innumerable separate and minute embryos. In the proglottids the increasing length of the paruterine organ could readily be observed owing to its extreme conspicuousness. It was so distinct from the rest of the proglottid in its neighbourhood, that each paruterine organ suggested a conical peg attaching two consecutive segments. In the living worms the paruterine organ is a perfectly rod-like structure, without any obvious twist of any kind. It was seen to diminish slightly in width at its terminal end, and was never seen to extend to the posterior end, though the organ appeared to commence at the very beginning of the proglottid. The whole appearance of the organ as seen with a lens, suggests that it is produced by a growth from before backwards, and not *vice versa*.

In alcohol-preserved examples the paruterine organ is no longer visible in the intact worm, nor is it in specimens examined whole after clearing but without staining. This seems to suggest that the bright white appearance of the paruterine organ in the living worm is caused by air-spaces in the spongy tissue of which the organ is composed. But it must be admitted that this of itself is difficult to understand. Still, the organ certainly has the appearance during life of being composed of a fine froth. I have examined the organ in the preserved worms by means of transverse and longitudinal sections. I have already spoken of the organ when fully developed as being rod-like, or perhaps rather style-like, as it diminishes to one end. But in transverse sections it is seen that the paruterine organ is only rod-like, and thus circular in section, in the fully mature proglottids. These proglottids are themselves tubular and oval, or even quite circular in transverse section. In more anterior segments the form of the proglottid is more flattened, and the paruterine organ shares in this alteration of form. In such proglottids the organ is more flattened and tends to have the

shape, in transverse sections, of a parallelogram with rounded angles. The most important point in the development of this organ is that it is wholly unconnected with the uterus. The paruterine organ is found in proglottids where there is as yet no trace of a uterus.

There can, therefore, be no comparison with the paruterine organ of such a form as *Avitellina*, "where the uterine wall cells . . . supply the origin of the egg-pouches or paruterine organ"\*. With reference to species of *Rhabdometra*, the statements of Ransom are not definite. In the case of *Rh. nullicollis*, that author writes† that "the parenchyma in front of the uterus becomes dense and fibrous and develops into a prominent paruterine organ, which behind is in immediate relation with the anterior end of the uterus." Of the paruterine organ of *Rh. similis*‡ he writes no more positively. We may infer from Mr. Ransom's descriptions that the paruterine organ does not appear before the uterus and that it may be an outgrowth of its anterior wall. In this case there is an important difference from the species described in the present paper, and in any case there is a difference in time of appearance.

The earliest appearance of the paruterine organ under a high magnification is shown in text-fig. 3. It consists mainly in an apparent multiplication of the nuclei of the medullary parenchyma. In any case they are more closely aggregated for a short region in the middle of the anterior half of the proglottid. This dense mass of nuclei—that is dense comparatively speaking—reaches forward to the anterior border of the proglottid. But it must be borne in mind that the actual delimitation of successive proglottids cannot be fixed unless the wall of the transverse water-vascular tube fixes it. In this case the paruterine organ does not reach the anterior limit of the proglottid in which it lies. In more mature proglottids, however, the anterior margin of the paruterine organ is so straight a line that one cannot help thinking that this may be the anterior margin of the proglottid, in which case the posterior wall of the transverse water-vessel lies within the segment in front.

I have no evidence whether the great multiplication of the numbers of the nuclei to form the beginnings of the paruterine organ is due to an actual multiplication, or to a crowding together by simultaneous migration inwards from other quarters. The nuclei of the future paruterine body show no difference from the surrounding nuclei of the medullary parenchyma. I have said that the multiplication of the nuclei is the main feature of the paruterine organ on its first appearance. The only other difference from the surrounding parenchyma is a slight opacity, which is, I am convinced, simply due to the crowding of the nuclei. The network structure of the medullary parenchyma is not at first at all altered in the future paruterine organ. The

\* Gough, Q. J. Micr. Sci. lvi. p. 375, 1911.

‡ *Loc. cit.* p. 34.

† Bull. U.S. Nat. Mus. No. 69, p. 29, 1909.

area occupied by the growing paruterine organ at this stage is rather more than a quarter and less than a third of the length of the proglottid. It is interesting to note that these small dimensions apply to the completely formed paruterine organ of *Rhabdometra nullicollis*\*.

Text-figure 3.



Portion of an anterior segment of *Rhabdometra cylindrica* in horizontal section, to show origin of paruterine body.

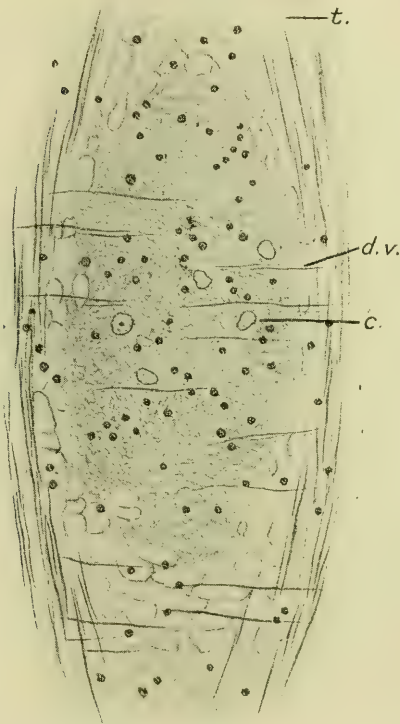
*l.* Longitudinal muscles. *par.* Paruterine organ. *t.* Testes. *t.v.* Transverse water-vascular vessel.

Text-fig. 4 illustrates a portion of a transverse section of a proglottid with a paruterine organ at a more advanced stage of development than that represented in the last figure. The paruterine organ is distinctly marked off from the surrounding

\* Ransom, *loc. cit.* p. 30, fig. 22.

medullary parenchyma in the middle of which it lies. But although it is definitely marked off, it has not an outer layer of circular muscles, such as will be described presently in the completely adult paruterine organ. The principal distinction which the paruterine organ shows in comparison with the

Text-figure 4.



Portion of a transverse section of a young proglottid of *Rhabdometra cylindrica*.

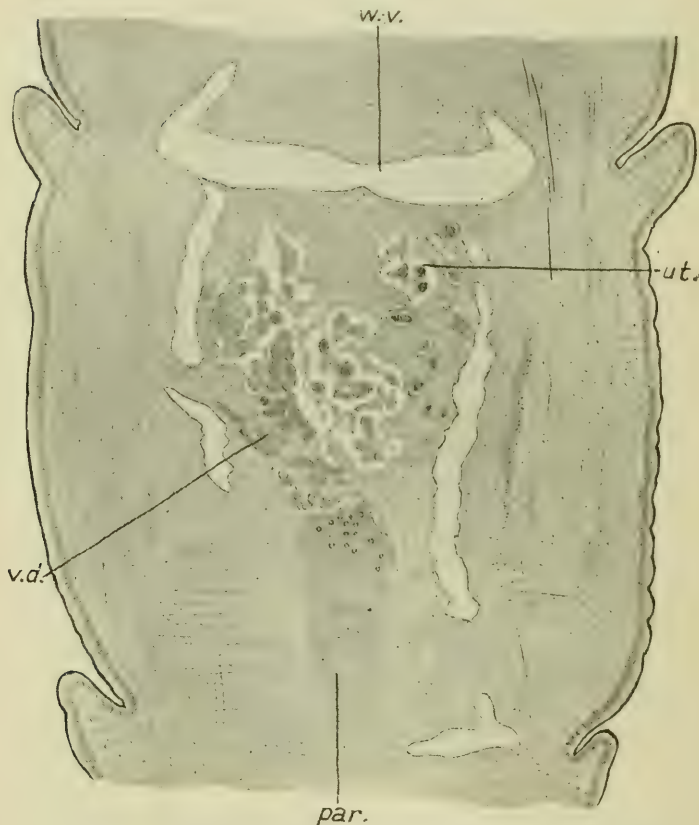
The greater part of the medullary region is occupied by the paruterine organ.

*c.* Calcareous corpuscles in the paruterine organ. *d.v.* Dorso-ventral muscular fibres. *t.* Transverse muscular fibres.

surrounding medullary region is the much denser character of the parenchyma, which no longer presents the appearance of a delicate network with clearer circular or oval interspaces. The network is here and there quite visible in parts, the whole tissue being much

more deeply stained. I take this to be due to a solidification of the tissue by the disposition of matter in the interstices of the originally existing network, which is more responsive to staining by logwood. The nuclei are more abundant than in the surrounding medullary parenchyma. But they are in the same way

Text-figure 5.



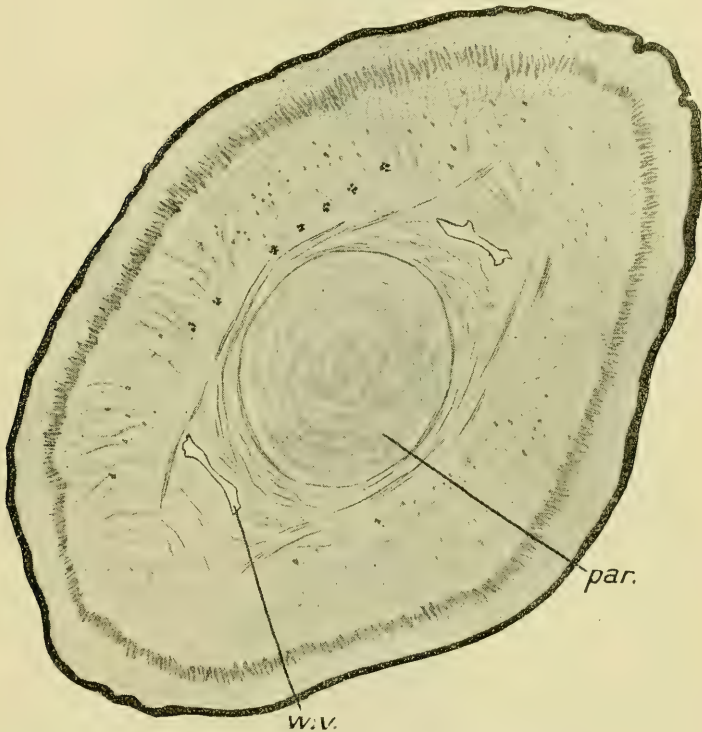
Horizontal section through not fully ripe proglottid of *Rhabdometra cylindrica*.

*par.* Paruterine organ. *ut.* Uterus appearing as numerous partly detached cavities. *v.d.* Vas deferens. *w.v.* Transverse water-vascular vessel.

of two kinds—larger and clearer nuclei which appear to be myoblasts, and smaller nuclei which belong to the connective-tissue network. A peculiar feature in the structure of the paruterine organ at this stage, and one which is a further proof of the view that it is a modified region of the medullary

parenchyma and not an outgrowth of the generative system, is the existence of dorso-ventral muscle-fibres: these are not elements belonging to the paruterine organ and restricted to it, but, as is shown in the text-figure referred to, they arise outside of and perforate it. They pass into the paruterine organ at exactly right angles to the transverse diameter of the proglottid. A final characteristic of the paruterine organ at this stage is the

Text-figure 6.



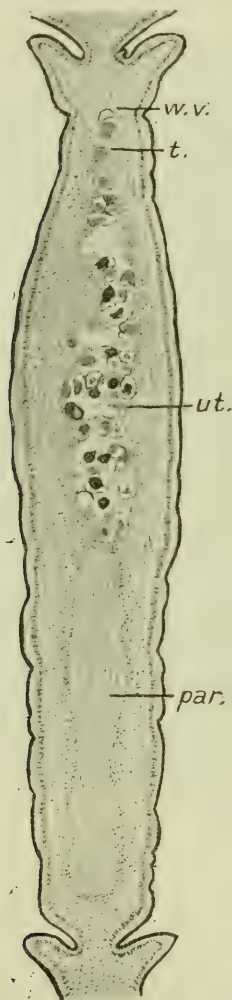
Transverse section through fully mature proglottid of *Rhabdometra cylindrica*.  
*par.* Paruterine organ. *w.v.* Ventral water-vascular vessel.

larger number of calcareous bodies which lie within it and which are most numerous where it abuts upon the uterus posteriorly. Ransom has remarked upon the same feature in the paruterine organ of *Sphyrnocolenia*. The shape of the paruterine organ at this stage as seen in horizontal sections is shown in text-fig. 5.

In the longest, and therefore presumably ripest, proglottids the paruterine organ differs in some few particulars from its younger

stages. In transverse sections, as is shown in text-fig. 6, the organ appears to be quite circular, and it lies exactly in the middle of the proglottid. It has sometimes a perfectly conical form tapering towards and at the end which touches, indeed protrudes

Text-figure 7.



Sagittal section through fully mature proglottid of *Rhabdometra cylindrica*.

*par.* Paruterine organ. *t.* Testes. *ut.* Uterus. *w.v.* Transverse water-vascular vessel.

into, the uterus. In other cases the diameter of the paruterine organ fluctuates from point to point, thus showing a less regular form such as is depicted in longitudinal section in text-fig. 7. This difference of form is probably to be explained by uneven contraction of the worm's body or the muscular wall of the paruterine organ during preservation. The paruterine organ is long, but not quite so long as the uterus at which it ends. It therefore occupies rather less than half of the length of the proglottid. Dorso-ventrally the paruterine organ touches the limits of the medullary region of the proglottid; but laterally it does not fill up that space entirely, leaving some of the original medullary parenchyma visible right and left. There is no question of the inclusion of any organs in the paruterine organ such as I describe later\* in what appears to be the equivalent of a paruterine organ in the Davaineid genus *Otiditernia*. The completely formed paruterine organ of this species of *Rhabdometra* is sharply marked off from the surrounding tissues by a layer of muscles disposed in circular fashion.

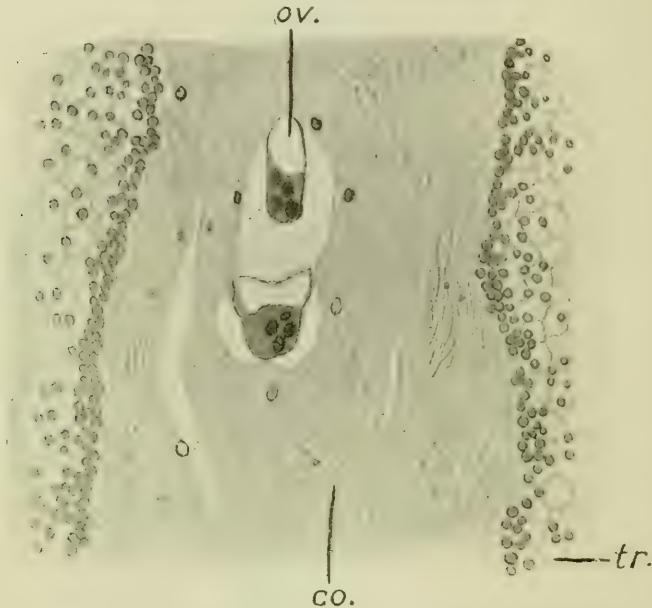
The existence of such an outer muscular wall to the paruterine organ has been noted by other observers. I believe this layer to be adventitious and for the following reasons. In the younger stage just described there is no muscular wall at all; but the innermost of the transverse muscular fibres tend to follow the outline of the oval paruterine organ, though they hardly can be said to adhere to it. The contraction, or at least the alteration, of the form of the paruterine organ into a circle in transverse section would tend to further a close relationship between itself and the immediately surrounding musculature. In any case such a relationship exists. The shape in section and the general form of the paruterine organ together with its muscular coat are not, however, the only points in which the adult organ differs from the less perfected stages. The tissue which fills it is apt to have a concentric lamellar arrangement shown in text-fig. 8; this is also visible in sagittal sections but is not shown in text-fig. 7, since the latter is not of a sufficiently highly magnified preparation. It is shown, however, in text-fig. 6.

In the younger proglottids (text-fig. 5) the paruterine organ ends up in close contact with the uterus, as has been already mentioned. It ends, however, in a definite border which is a straight line. In the completely developed paruterine organ there appears to be an absolute continuity, and the connective-tissue core of the paruterine organ melts away, as it were, in the cavity of the uterus. It appeared to me that the calcareous corpuscles, which are apt to be specially abundant on the paruterine organ at its distal end though found throughout it, are both smaller in many cases and generally less abundant in the older paruterine organ. It looks as if they were used up perhaps by the growing embryos. Furthermore, the "perforating" dorso-

\* P. 880.

ventral muscles, to which I have referred in the younger paruterine organ, are in places, but by no means always, visible in the adult, as may be seen by a comparison of the figures given. They are perhaps broken by the swelling of the organ to a circular form in section, for I have seen short fibres imbedded in the connective-tissue core.

Text-figure 8.



More highly magnified view of a portion of the paruterine organ in sagittal section.

co. Tissue of paruterine organ with calcareous bodies. ov. Ripe eggs contained in a space within the paruterine organ. tr. Transverse muscles.

In describing the paruterine organ of *Chapmania tapika*, Prof. Fuhrmann\* remarks that in that and all forms with a paruterine organ the ripe eggs do not pass into the paruterine organ until the proglottids are detached and thus ready to leave the body. Mr. Ransom† particularly remarks that in his examples of the genus *Sphyrnecotenia* the mature segments showed no eggs within the paruterine organ and that the mode of their transference was thus unknown to him. This state of affairs is nearly true also of the *Rhabdometra* which forms the subject of the present communication, but not quite. In one ripe proglottid among many which I studied, I found embryos within the

\* Res. Swed. Zool. Exp. Egypt, pt. iii. No. 27, p. 19, 1909.

† Proc. U.S. Nat. Mus. vol xl. p. 637, 1911.

paruterine organ, thus incidentally proving that the organ is a paruterine organ, if any doubt could be supposed to attach to that identification of it. The embryos were not directly imbedded in the lax tissue of the paruterine organ but were accompanied by a cavity within which they lay. Whether this means that their assumption into the paruterine organ resulted in the formation of a cavity by stretching or other means, or whether a portion of the uterus was detached as a whole and engulfed by the paruterine organ, I do not know.

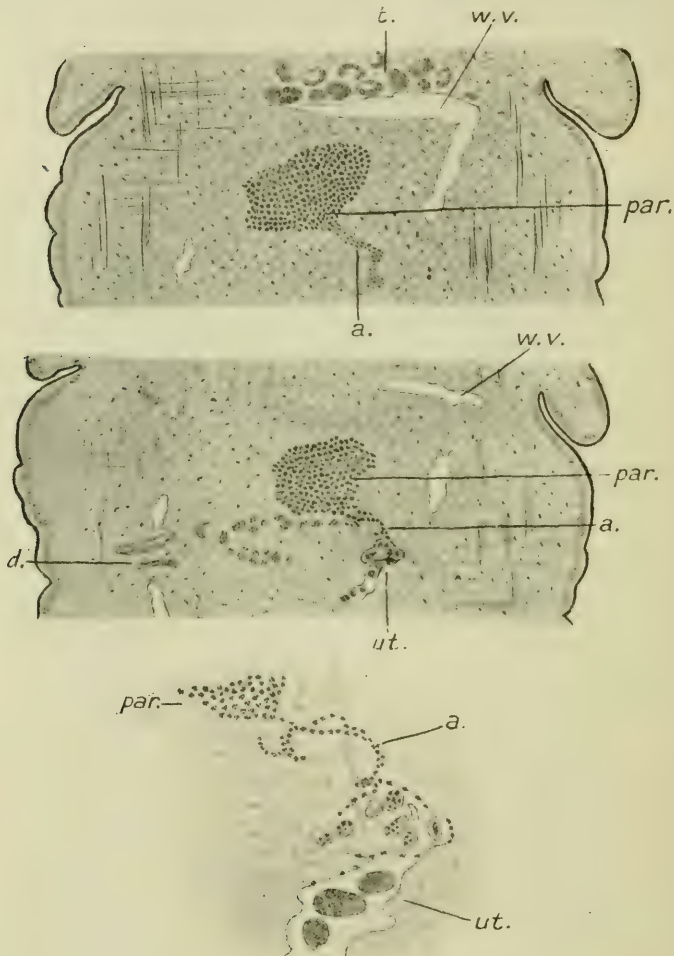
### § *The Uterus.*

Although the appearance of the paruterine organ before the uterus is developed proves that the former is not a product of the latter, it does not follow that there is no connection at all between these two organs in their origin. I believe that I have been able to establish a connection between the two, and that the tissue of the paruterine organ gives rise to the uterus. I am not sure that I have detected the uterus in the very first segment in which it is developed, but if not, I am not more than three or possibly four segments out. As is often the case with tapeworms, the uterus appears rather suddenly and in an advanced stage of development, at least speaking relatively. In the segment in question, which is the second or third with a uterus, the testes are still active and the ovary and vitelline glands in full maturity and not beginning to degenerate. The paruterine organ is considerably younger than that represented in text-fig. 5; in the sections (which were nearly accurately horizontal) the outline of the paruterine organ was nearly square, the breadth being a little greater than the length. The uterus consists of an irregular tube running rather obliquely across the long axis of the body. The tube branches somewhat and there are indications of anastomoses; but the retiform stage of the uterus has hardly been reached. The uterus does not extend, as it does later, in front of the transversely running coil of the vas deferens. It does not, therefore, come into contact with the broad posterior end of the paruterine organ as it does in later stages (*cf.* text-fig. 5). There is, however, a connection between the two which is more than mere juxtaposition and is, therefore, of an interesting nature. A process extends backwards from that posterior corner of the paruterine organ which is furthest away from the pore side of the segment. It consists, like the paruterine organ at this stage, of little more than an agglomeration of nuclei. This process extends backwards until it reaches the uterus with whose walls it is continuous.

In an earlier stage, about three segments in front of that just described, a uterus can hardly be said to exist. I detected, however, a thread of paruterine tissue extending towards the same side of the body; this came into close relations with one or two spaces containing ripe ova situated in front of the uterus,

and perhaps to be looked upon as the first appearance of a uterus.  
I figure also (text-fig. 9) from a segment which is the one in

Text-figure 9.



Upper figures represent two horizontal sections through immature proglottids of *Rhabdometra cylindrica*.

Lower figure a more highly magnified view of the connection between the paruterine organ (*par.*) and the uterus (*ut.*).

*a.* Process of paruterine organ connecting it with uterus. *d.* Dorsal vessel.  
*w.v.* Transverse water-vascular vessel. *t.* Testes.

front of that first of all treated of in the present account of the development of the uterus of *Rhabdometra*. Here the connection of the paruterine organ with the uterus happens to be plainly visible in one section, and, therefore, to be more striking and less liable to doubt than when it has to be followed out from section to section. Furthermore, in subsequent sections, where the uterus is more advanced and lies also in front of the vas deferens, the tissue of the paruterine organ is seen to pass continuously into that of the uterus, and the nuclei of the walls of both appear to be identical.

These facts—that is to say if it be agreed that they prove a connection between the paruterine organ and the uterus—enable us to get over certain morphological difficulties relating to the homologies of the uterus and paruterine organs of some other Tapeworms.

In describing the structure of *Inermicapsifer capensis*\* I had to refer to an important difference in the uterus of this form as compared with other species referred by v. Janicki† to that genus (his own). Briefly put, the difference is this: in *I. capensis* there was no continuous uterus, but only a series of detached cavities which appeared to be formed independently in the medullary parenchyma. These cavities were formed subsequently to the extrusion of the ova from the ovary and their scattering through the parenchyma of the medulla. Furthermore, there was also to be observed, and again unconnected with the ova at first, a condensation of the medullary nuclei to form a kind of network pervading the medulla. This network was often to be observed in relation to the ova‡.

Out of this dense tissue, which ultimately surrounds the ova, is formed the series of paruterine organs which characterise this, as well as a few other genera of tapeworms (*Davainea*, *Thysanotenia*). I held that the network of parenchymal tissue, out of which the paruterine organs were formed, and the cavities in which lay the eggs singly or in groups, were not the equivalents of the branched uterus described by v. Janicki in an allied form, *Inermicapsifer hyracis* (which I removed to the genus *Zschokkeella*), because, if it were, it would be a subsequent stage due to the obliteration of the pre-existing cavity; and as the ova appeared in it later it could not be a subsequent stage. I believe that the matter becomes clear through the observations which I have recorded in the present paper. We have in *Rhabdometra*, as in *Inermicapsifer*, a condensation of nuclei to form structures or cavities to contain the eggs. In *Rhabdometra* there is one extensive condensation of the kind to form the paruterine organ and a delicate strand which extends through part of the rest of the medullary parenchyma and would appear to be the seat of the formation of the uterus. In my species of *Inermicapsifer* there is the same condensation of the

\* P. Z. S. 1912, p. 588, etc.

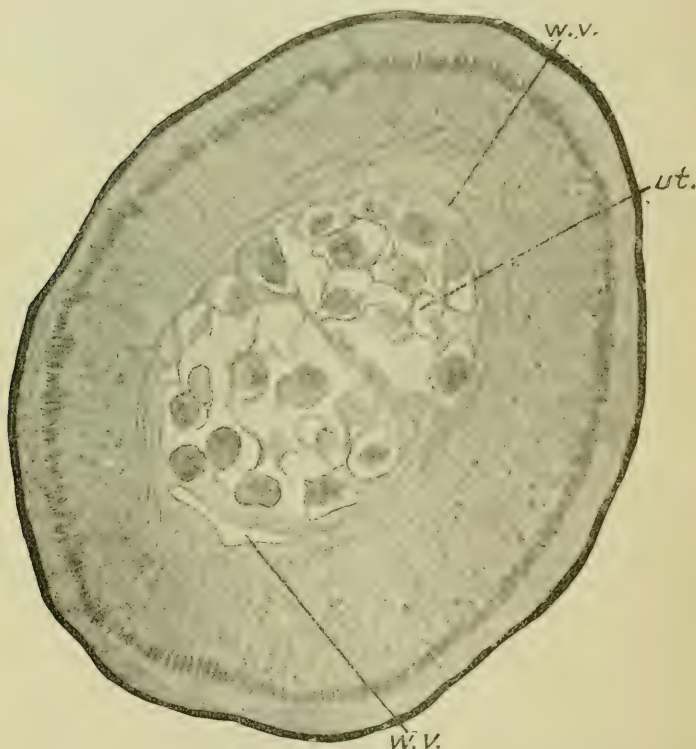
† Jen. Denkschr. xvi. 1910.

‡ Beddard, *loc. cit.* text-fig. 67, p. 588.

medullary parenchyma, but it does not become much hollowed out to form a uterus or specially condensed in one part to form a single paruterine organ.

On the contrary, it is condensed here and there to form several paruterine organs. In *Inermicapsifer hyracis* of v. Janicki, a hollowing out of the strands of condensed tissue occurs before the further condensation of the medullary tissue to form the numerous paruterine organs. I am of opinion that all these rather various

Text-figure 10.



Transverse section through mature proglottid of *Rhabdometra cylindrica*.

ut. Uterus. w.v. Lateral water-vascular tubes.

cases are upon one common ground plan, which does away with the at first apparent differences of importance between such closely allied forms as *Inermicapsifer capensis* and *Zschokkeella hyracis*; and also relegates to the same category other forms in which there is but a single paruterine organ. If these suggestions thus briefly sketched out be not accepted, there still remain the

Facts which I have described above in connection with the formation of the uterus in *Rhabdometra cylindrica*. I have mentioned that the uterus soon after its formation is distinctly retiform, the network being irregular but very plainly to be seen in horizontal sections. In transverse sections, the uterus is seen to lie ventrally and to consist of variously sized cavities detached from each other, which is, of course, the expression of the horizontal network when seen in that aspect. In more mature proglottids the retiform condition is not so clear and the uterus occupies much more of the proglottid. The arms of the network seem to have coalesced, forming an irregularly shaped body with partial septa dividing its interior into partly detached cavities, and with outgrowths producing a general irregularity of surface. In the completely mature proglottids the appearance of the uterus has again changed owing to further development. Text-fig. 10 shows a transverse section of such a proglottid, and the contained uterus is seen to be circular in section and thus to be rod-like in form. Posteriorly the uterus is divided by a median septum into two equisized halves, but further forward the uterus is obviously single, but the interior is divided by many ingrowing strands of the medullary tissue into a series of chambers each of which is seen to lodge but a single embryo. The posterior division of the uterus into two reminds us of the uterus of *Rhabdometra nigropunctata* as figured by Crety\*; it is possible, however, that the latter form is rather to be referred to the genus *Metroliasthes*, in which the uterus is an entirely double structure. The series of changes in the appearance of the uterus in this species of *Rhabdometra* is very remarkable, and seems to contrast with what has been observed in the other species of the genus. It is further to be noted that we have here, as a temporary phase, a form of uterus which is now characteristic of one genus of Tapeworms and now of another.

From the above account we can abstract the following description of the species :—

*Rhabdometra cylindrica*, sp. n.

Length 150 mm.; greatest diameter 1.2 mm. Scolex of less diameter than strobila following, suckers proportionately very large; rostellum and hooks absent. Neck absent; posterior segments elongated, five times their diameter, cylindrical in form. Genital apertures alternate irregularly, behind middle of proglottid. Genital ducts pass between water-vessels and ventral of nerve-cord. Cortical layer thick; longitudinal muscles not in strong bundles; mostly implanted singly, but a row next to transverse layer of widely spaced bundles with from two to five or six fibres. Circular layer

\* Boll. Mus. Torino, 1890. In Crety's figure the two posterior and globular diverticula of an anterior curved portion are alone represented as containing eggs: I assume, therefore, that the anterior part is all of it to be regarded as a paruterine organ.

well marked and also occupying, in the form of scattered fibres, most of the medullary layer in the region of the paruterine organ. Dorsal water-vessel very small, lying dorsal of large ventral vessel, which communicates with its fellow posteriorly in each segment by a single transverse vessel; no excretory network. Testes surround ovary and vitelline gland. Cirrus-sac with a strong muscular wall, and with special retractor muscles posteriorly, long and narrow, extending a little beyond water-vascular tubes; cirrus without spines; vas deferens with a large and close coil but without vesicula seminalis. Cirrus-sac opens into a cloaca genitalis. Vagina opens behind cirrus-sac, terminal region wide and muscular. Uterus at first retiform, then irregular in shape with outgrowths, later tubular and divided into two chambers by a median septum posteriorly; the embryos also separated by ingrowths of walls of uterus. Paruterine organ long and styliiform, commencing at anterior end of proglottid, nearly circular in transverse section when mature, appears before uterus.

Hab. *Caccabis melanocephala*.

### § Systematic Position.

It is clear that a member of the Tænioidea with a totally unarmed scolex, with one set of genitalia in each proglottid, and with a single paruterine organ, can only belong to one of the three genera *Rhabdometra*, *Anouchotania*, or *Metroliasthes*, or to a new genus allied to them.

As it is, these three genera are very near together; the generic differences as set forth by Ransom mainly concern the position of the genital ducts with reference to the water-vessels and the form of the uterus. In both of these particulars the present species is like *Rhabdometra*; sufficiently so also, in other features, to warrant its inclusion in that genus. There are, however, differences which prevent the reference of my species to any of those which have been already described. In none of the hitherto described species are the segments so long as in the present form. *Rhabdometra nigropunctata* has the longest of any; but here the most posterior are only  $3 \times 1$ .

There is, to my mind, no doubt that the species which is nearest akin to that which I here name *Rhabdometra cylindrica* is Fuhrmann's recently described *Rh. numida*\*, and it will be observed that both come from the same part of the world and they both infest gallinaceous birds. There are, however, sufficient differences to warrant specific separation. Thus, *Rh. numida* is a small species 60–70 mm., and has not, as already mentioned, elongated posterior proglottids. Although the two species agree in possessing a long cirrus-sac, that of *Rh. numida* is much the longer, reaching as it does to the middle of the body. Nothing is said as to the development of

\* Res. Swed. Zool. Exp. Egypt, Pt. iii. No. 27, p. 36, 1909.

the uterus; but it is, when fully matured, a lobate sac, and apparently not strictly cylindrical, as in my species. On the other hand, the paruterine organ is represented as appearing first, and the course of the vas deferens is as in my species and not as in some others. Further, the genital apertures of *Rh. numida* are behind the middle line of the proglottid, and the testes come nearer to surrounding the ovary than in other species, except *Rh. cylindrica*. Finally, the generative ducts lie between the water-vessels and ventral to the nerve-cord. I have observed the same relationship in *Rh. cylindrica*.

It is possible, of course, that previous authors have not seen quite fully-developed examples of the species studied by them. In view, however, of the published figures of the uterus and paruterine organ in the several species, I am inclined to doubt this. For example, Ransom's figure of that organ in *Rh. similis*\* shows the "flowing appearance" of the core of the paruterine, which I find only in that organ when fully developed (see text-fig. 8, p. 872). As to other species, it does not appear that the reticular uterus of *Rhabdometra cylindrica*, a condition which precedes its cylindrical final form, has any likeness to what has been observed in previously described forms. This, indeed, coupled with the form of the paruterine organ and a number of minor points, such as the posterior position of the generative apertures, the position of the coil of the vas deferens, and the distribution of the testes, seem perhaps after all to necessitate generic separation. But this I leave for the present. It must be remembered, however, that the scolex of this species of Ransom is unknown, and that apart from this character it is hard to distinguish *Rhabdometra* from *Paruterina*.

#### § *A Note upon Otiditænia eupodotidis* Beddard.

After communicating to the Society † my note upon this new tapeworm from *Eupodotis kori*, it was suggested to me that it was possibly identical with or near to a recently described new genus and species *Sphyruncotænia uncinata*. I had not at that time seen Mr. Ransom's paper ‡, which only (through his kindness) reached my hands after my memoir was in the press. I was, therefore, unable to make any comparisons. A consideration of the structure of this genus *Sphyruncotænia*, leads me to revise what I have written concerning the affinities of *Otiditænia*; but the two genera are not identical. In *Sphyruncotænia* the body is much more elongate than in *Otiditænia*; the genital pores are unilateral; there are many rows of minute hooks upon the rostellum, and the uterus appears to be racemose and to extend

\* *Loc. cit.* p. 35, fig. 26.

† P. Z. S. 1912, p. 194.

‡ Ransom, "A New Cestode from an African Bustard," Proc. U.S. Nat. Mus. xl. p. 637, 1911.

much further into the ripe proglottid than it does in *Otiditænia*. I have re-examined my preparations of *Otiditænia*, and find that my report upon its structure as regards the above points in which it differs from *Sphyruncotænia* is correct as to fact.

But I find that I have missed one point of resemblance to *Sphyruncotænia*, and through it, to the subfamily Idiogeninæ of the Davaineideæ. This has, of course, an important bearing upon the classification and position of *Otiditænia* in the system. While admitting its resemblances to *Davainea*, and by inference to the Davaineideæ, I was inclined to place *Otiditænia* nearer to *Choanotænia* and its allies. This was, undoubtedly, due to my not having seen a paruterine organ, though its presumed absence was not made use of in the generic definition\*, or in the résumé of the most noteworthy characters of the genus following the definition. Nor, indeed, do the nearly mature proglottids show any structure exactly resembling the paruterine organ of *Idiogenes*, *Stilesia*, *Anonchotænia*, *Sphyruncotænia*, *Rhabdometra*, and other forms as figured by various zoologists in memoirs known to me. In all of these instances, and in others, the paruterine organ is represented as a structure of fibrous appearance and of limited size, formed apparently from a metamorphosis of the medullary ground-tissue in the immediate neighbourhood of the uterus or from the walls of the uterus itself. This latter origin is asserted by Gough† for *Avitellina centripunctata*, while Ransom's figure‡ of a "mature segment becoming gravid" of *Rhabdometra similis* may be interpreted in a like manner. But whatever be the origin of these paruterine organs§—and both Fuhrmann and Gough believe them to be not strictly homologous through the series—they would appear to have been described as small bodies lying in, and possibly derived from, but ultimately independent of, the medullary parenchyma.

In *Otiditænia*, however, the more mature segments show an alteration in the medullary parenchyma to which I have referred, and which I have figured in my memoir upon that genus||. This alteration affects the whole of the medullary parenchyma as seen in that section¶ of a nearly mature proglottid. It is visible up to the circular muscular layer which forms the line of demarcation between the cortex and the medulla, except where it is separated therefrom by the ventral water-vascular tube as is also shown in my figure. The dorsal smaller water-vascular vessel lies well within the core of medullary parenchyma, as is also shown in the figure referred to. There is not, therefore, to be

\* *Loc. cit.* p. 220.

† "A Monograph of the Tape-Worms of the Subfamily Avitellininzæ." *Quart. Journ. Micr. Sci.* lvi. pt. 2, 1911, p. 375.

‡ "The Tænioid Cestodes of N. American Birds." *Bull. U.S. Nat. Mus.* No. 69, 1909, fig. 23, p. 31.

§ I do not refer here to the multiple paruterine organs of *Davainea*, *Zschokkeella*, etc.

|| *Loc. cit.* p. 218, text-figs. 23, 24, 26, 29.

¶ *Loc. cit.* fig. 29, p. 212.

observed the formation out of the medullary parenchyma of a definite structure that can be called a separate organ, since the modified region of the proglottid extends over the whole medullary parenchyma and includes the dorsal vascular tube.

I have also figured in my paper referred to stages which are anterior to that which has just been redescribed. In text-fig. 26 of the paper referred to\*, three proglottids somewhat younger are represented in sagittal section. A glance at this figure might convey the suggestion that a definite paruterine organ of limited extent lay in each of these proglottids, narrower at one end (where the letter "T" in the diagram is placed) and wider at the other. Furthermore, the slightly twisted outline of the (alleged) paruterine organ recalls that of, for example, *Rhabdometra nullicollis*†. A more careful scrutiny of these sections, however, brings to light the following facts which are of importance in the matter. Although, as depicted in my illustration, the edge of the (alleged) paruterine organ is apt to be wavy and thus to create inequalities in its diameter, suggestive of a solid body of irregularly curved outline, it will be found that the waviness is closely followed by the layer of transverse musculature which separates, in this as in other tapeworms, the cortical and medullary layers. Unequal contraction during preservation is, as I think, responsible for this undulating disposition of the line of transverse muscular fibres. The object, however, of my figures referred to was not to show the structure of the medullary parenchyma but to indicate the position and relations of the uterus. The minute structure of the medullary region in this stage is less modified than that of the older proglottids already referred to. The medullary groundwork is traversed by numerous rather stout muscular fibres, running mainly if not entirely in a dorso-ventral direction. These are very frequent, but are single and not aggregated into bundles excepting at the anterior end of the proglottid; here the testes of this segment in front are separated by a thicker layer of these muscles from the parenchyma of the ensuing segment, the groundwork is comparatively dense, and there are abundant nuclei. I have recognised that in those proglottids, as well as in the more mature ones, the dorsal water-vessels are included in the medullary tissue. In comparing this stage with the older one that has just been described, it appears that the latter differs only in the degeneration of the muscular fibres of the ground-tissue, which produces the more fibrous and, at the same time, laxer appearance of the medullary parenchyma, which, however, may be more resistant, and which is still further exaggerated in the distended perfectly ripe and detachable proglottids at the end of the worm's body. This laxity favours the movement into the interior of the embryos from the uterus, which I have described in my paper as occurring in

\* P. 204.

† Ransom, Bull. U.S. Nat. Mus. No. 69, p. 29, fig. 21, 1909.

these proglottids. It should, furthermore, be noticed that while the medullary tissue is, as already stated, separated anteriorly from the testes, there is no such separation posteriorly where it abuts upon the uterus, nor is the epithelial lining of the latter apparent in these older proglottids; thus the transference of the eggs into the medullary parenchyma is rendered easier. Finally, I have observed that the calcareous corpuscles tend to accumulate more thickly where the medullary parenchyma touches the uterus, though they are also present elsewhere and in some numbers here and there.

To compare with the above older stages in the growth of the sheltering apparatus for the developing embryos, I have again studied younger stages such as is represented in text-fig. 25 of my paper referred to\*. I have, however, more especially studied sagittal sections, as in the case of the older proglottids. In such sections there should be visible the origin of the paruterine body, were this structure in the genus *Otiditænia* of the same nature as that of *Rhabdometra*, etc. But I can find no trace of any particular condensation and fibrillation of a definite region of the medullary parenchyma which might later spread and involve the whole region, which is thus involved in mature proglottids, but for other reasons.

Not only is there nothing of this kind to be observed in the less mature proglottids, but there is no approach towards the fibrous appearance of the mature proglottids. This latter appearance is, in fact, produced by a new growth, which seems to be very remarkable. I have already referred in my account of the proglottids of intermediate age to abundant dorso-ventral muscular fibres in the medulla; it is, perhaps, to the unequal contraction of these by the preservative reagent that the irregular outline of the medullary parenchyma is due, which I have commented upon as simulating a paruterine organ of limited extent, lying in the medullary parenchyma. I now call attention again, in a more particular way, to these muscle-fibres. In his account of tapeworms of the subfamily Avitellinæ (of the family Anoplocephalidæ), Gough † enters in some detail into the histology of *Avitellina centripunctata*, including that of the muscular system, which I may conveniently take as a basis of comparison with *Otiditænia*, which shows an important difference. Gough points out that the dorso-ventral muscles which traverse the medullary parenchyma in that direction, consist mainly of bipolar myoblasts with terminal fibrillæ and, to a less degree, of bipolar myoblasts with lateral fibrillæ. The larger muscular fibres, which are tubiform with an axially contained myoblast, are limited to the longitudinal muscular layer. My own observations upon various genera which I have examined confirm this generalisation. The delicate dorso-ventral muscle-fibres of such

\* *Loc. cit.* p. 202.

† Quart. Journ. Micr. Sci. vol. lvi. 1911, p. 347 *et seq.*

tapeworms as I have known hitherto, often curled into a spiral or at least an undulating course, are excessively slender as compared with the longitudinal muscles. In *Otiditania*, however, we meet with the very surprising state of affairs represented in the annexed figure (text-fig. 11). Imbedded in the nucleated parenchyma are numerous scattered muscular fibres, which have a general

Text-figure 11.

Sagittal section through a portion of proglottid of *Otiditania eupodotidis*.

*l.* Longitudinal, *t.* Transverse, *d.v.* Dorso-ventral muscles.  
*m.* Medullary layer.

dorso-ventral direction and must be regarded as the dorso-ventral musculature. But the fibres themselves are distinctly of the character of the fibres of the longitudinal muscular layer. They are long, straight fibres of even diameter, and I traced them through the layer of circular fibres which bounds the medullary

parenchyma externally. These fibres, however, are not exactly like those which constitute the longitudinal muscular bundles. Although very wide when compared with the delicate fibrils that one expects to find in this situation, they are little if anything more than half the width of the longitudinal fibres. There is also a difference in the way in which they absorb the logwood stain, indicating a denser, because more deeply stained, outer layer. I do not attempt a further description of these fibres, as the material was not preserved in a way likely to bring out greater detail of structure. But enough is plainly visible to show that the dorso-ventral musculature in this worm is different from that usually met with in this situation among tapeworms. It is now necessary to point out that, in the younger proglottids, these thick dorso-ventral muscles are not visible. As the mode of preservation and staining has been identical, there can be no question here of a failure to detect the fibres in question, which I have looked for both in transverse and sagittal sections. Fine delicate fibrils can be seen, but nothing like the muscles just described, which are even recognisable under quite low powers. It seems clear, therefore, that they appear; but whether they do so in the shape of new fibres or of a thickening of more slender fibres present in the younger proglottids, I am unable to say. But in any case there is a change of structure in the medullary parenchyma as it grows older which is not a degeneration, and which appears, therefore, to be a preparation for some function, which is possibly that of a receptacle for the ripe embryos. It is for these reasons that I think myself justified in speaking of a paruterine organ in *Otiditænia* which is, however, of a most generalised kind.

The above description amounts in reality chiefly to an emphasised re-assertion of the facts concerning the medullary parenchyma of *Otiditænia*, already dealt with in my paper on that genus. The facts lead me to the inference that we have in this tapeworm the commencement of the formation of the paruterine organ, which is more differentiated in other genera of Davaineidæ, as well as in the Paruterinæ among the Hymenolepididæ. The paruterine organ of *Stilesia*, and that of its immediate ally *Avitellina*, seems to me to be a different structure altogether, though serving much the same function. In *Otiditænia*, then, there is an alteration of structure in the whole medullary layer in the direction of increased firmness; but there is no special part of that parenchyma set apart for the sheltering of the growing embryos. In a sense, therefore, I was right in not describing the existence of a paruterine organ; but with equal truth it may be said that this genus has the equivalent of a paruterine organ. In this genus we see the next stage to that exhibited by many genera in which the ripe embryos lie in the unaltered parenchyma, such as *Oochoristica*, *Linstowia*, etc. A slight increase of specialisation of the conditions observable in *Otiditænia* leads us at once to such a form as *Sphyrnoscotenia*,

where a large conical paruterine organ exists which is distinct from the surrounding medullary parenchyma.

### § *Systematic position of Otiditænia.*

I shall now reconsider the systematic position of *Otiditænia* in the light of the foregoing revision of certain facts in its anatomy.

As to the hooks which would form so important a means of preliminary family identification, I am not yet certain whether they are or are not the typical Davaineid hooks. They may well be so; but as I have not been able to view them sideways in my preparations I am unable to be positive. They may prove to be like those of *Oligorchis paucitesticulatus* \* for example. There is, however, no doubt that this genus is not in any case a near ally of *Oligorchis* or *Hymenolepis*, so that we may perhaps fairly assume that the hooks after all conform to the idea that *Otiditænia* is to be referred to the Davaineidæ. Of this family Mr. Ransom has lately† made a useful table of classification which is an extension quite up to the present date of the table in his revision of the Cyclophyllideæ‡.

From the table in question it appears that *Otiditænia* will come nearest to *Chapmania*. The matter for immediate settlement is, therefore, whether the two genera are to be regarded as identical, in which case my name will obviously have to be dropped. It must be remembered, however, that this near alliance depends upon whether we are to look upon *Otiditænia* as possessing a paruterine organ; otherwise (still considering it for other reasons to be a Davaineid) *Otiditænia* will be nearer to, or identical with, either *Davainea* or *Ophryocotyle*. As to *Davainea*, we may at once dismiss the idea of near affinity; for in that genus the ripe embryos are included in numerous separate paruterine sacs quite unlike the paruterine organs of Idiogeninæ. The knowledge of the genus *Ophryocotyle* mainly depends upon the descriptions of *O. insignis* of Lönnberg, the most recent of which is in a memoir by Fuhrmann§. This worm is to be at once distinguished from mine by the immense number of hooks, 2000, which are disposed in an undulating line round a particularly large rostellum; furthermore, the uterus, which is slightly lobate in form, lies behind the ovary, while the testes are dorsal to as well as behind the ovary. Moreover, the uterus shows no tendency to break up; it is conceivable, however, that it might later, in view of the very late breaking up of the uterus in *Otiditænia*. Finally, *Ophryocotyle* is to be characterised by multiple rows of minute hooks upon a portion of the suckers. This latter character does not seem to be found in *Otiditænia*.

\* Fuhrmann in "Nordische Vogel-Cestoden aus dem Museum von Göteborg," Medd. Göteborg. Mus. Zool., Afd. i. p. 18, fig. 8.

† "A New Cestode from an African Bustard," Proc. U.S. Nat. Mus. xl. 1911, p. 637.

‡ Bull. U.S. Nat. Mus. No. 69, 1909.

§ Centrabl. f. Bakt. Paras. Bd. xlix. 1909, p. 94.

But in the case of these hooks upon the suckers, it would appear that in *Chapmania* they tend to drop off. This difference, therefore, between *Otiditenia* on the one hand, and both *Ophryocotyle* and *Chapmania* on the other hand, must be held in reserve until more specimens have been examined. There is, however, I think, no doubt that *Otiditenia* is quite distinct from *Ophryocotyle*, if only by reason of the characteristic rostellum of the latter. There now remains only the genus *Chapmania*. The first obvious point of difference between the two supposed genera is the armature of the suckers in *Chapmania*; but, as already admitted, we cannot apparently dwell too strongly upon this, for the reason that these hooks are said to be occasionally shed from the suckers in *Chapmania*. I have, however, examined the suckers in two specimens of *Otiditenia*; and the examination of two examples lends naturally further support to the view that the hooks are really missing. Apart from this, there are apparently two main points of difference which forbid a fusion of these genera. In *Chapmania tapika*—which species alone comes into comparison with *Otiditenia*, for *Ch. taurika* has unilateral generative pores and in other respects differs perhaps to a generic extent from its supposed congener—a tentacle arises from each sucker; this is figured by Fuhrmann as elongated and conical. I have found nothing of the kind in longitudinal and transverse sections of the scolex of *Otiditenia*. It may be urged that this failure to discover a similarity may be due to the complete retraction of the sucker tentacle, and thus to the difficulty of detecting it. This may be so; but in the meantime I have seen, in a tapeworm from *Numida* (which may perhaps be the very species, *Chapmania tapika*), the tentacle freely moving about in the living worm. Having thus recognised the structure, it is of course less likely that I should miss it in examples where it was carefully looked for. Besides, the apparent non-retraction of this tentacle in the preserved examples of *Chapmania* examined by Fuhrmann, leads to the inference that it would be present in an unretracted condition in my spirit-preserved specimens of *Otiditenia*, were it a character of that species. The next point of difference is the paruterine organ. If we are to regard the modified medullary parenchyma in its entirety as the paruterine organ in *Otiditenia*, the corresponding organ of *Chapmania* as figured by Clerc\* is distinctly different.

Neither Fuhrmann nor Clerc gives much in the way of description of the organ. Judging from the figure the paruterine organ of *Chapmania* only occupies about half of the ripe proglottid. It extends towards the uterus, which occupies about the other half, and ends on its side turned towards the uterus in a flat surface. This is obviously totally different from the structure which I have figured in *Otiditenia*, and considered to be possibly a paruterine organ. On the other hand, the breadth of the

\* Centralbl. f. Bakt. u. Paras. Bd. xlii. 1906, p. 722.

paruterine organ in *Chapmania* lends some support to a comparison; for it is as wide as the medullary parenchyma, which it entirely fills anteriorly, thus contrasting with the much narrower paruterine organ as figured in *Idiogenes*. I should also add that the supposed paruterine organ of *Otiditenia* has no line of demarcation from the uterus such as is figured by Clerc in *Chapmania*. As points of minor importance, the uterus is lobate in *Chapmania* and ends much further forward in the segment than it does in *Otiditenia*. The ripe and detached proglottid figured by Fuhrmann \* is apparently not unlike that of *Otiditenia*. But it may be seen that the paruterine organ is more or less completely filled with the ripe embryos, whereas in *Otiditenia* as I have mentioned, the ripe embryos are not scattered throughout the whole of the supposed paruterine organ.

The testes of *Chapmania* are described as being dorsal, whereas in *Otiditenia* they are posterior, and no more dorsal than ventral. Concerning the muscular system of the genus *Chapmania*, there is a difference of opinion between Fuhrmann and Clerc. The latter regards it as feebly developed, the former as strong; in the latter event *Otiditenia* agrees with *Chapmania*. One would like to know something of the genera *Ascometra* and *Schistometra* of Cholodkovsky, which are to me at present merely names, being included in a Russian catalogue of parasitic worms †. As these genera occur in Bustards they are quite possibly Davaineids. I do not attempt to redefine *Otiditenia* until I learn whether it be held by others that the paruterine organ described above is a structure referable to that category, and therefore of great importance as a generic character among the Davaineidæ, to which family I now distinctly refer *Otiditenia*.

\* Res. Swed. Zool. Exp. Egypt, Pt. iii, No. 27, p. 22, fig. 16, 1909.

† Cf. Zool. Rec. 1912.



49. On the Feet and other External Features of the Canidæ and Ursidæ. By R. I. POCKOCK, F.R.S., F.L.S., F.Z.S., Curator of Mammals.

[Received May 19, 1914: Read June 9, 1914.]

(Text-figures 1-13.)

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### Family CANIDÆ.

Apart from the feet, the external features dealt with in this paper are the rhinaria and the facial vibrissæ.

The feet of the typical Canidæ are highly specialised, and show a close adaptive resemblance to those of the Felidæ in the form of the plantar pad, the strong curvature of the line of the pads of digits two to five, in the backward position of the first digit of the fore foot, its absence from the hind foot, the hairiness of the area behind the plantar \* pads, and the persistence of the single carpal pad on the fore feet. In their structural uniformity within the families, the feet of the Canidæ and Felidæ show a marked contrast to those of the Viverridæ, Mustelidæ, Procyonidæ, and Ursidæ.

In most wild species of Canidæ the feet differ only in minor points from those of domestic breeds already described †. The four principal digits are united by integument up to the base of the pads. The webbing thus formed may be wide or narrow, and clothed with longer or shorter hairs, according to the species. As in other Fissiped Carnivora, the hair grows in tufts between the pads of the feet and on the upper side of the webs. It is usually thickest and longest on the webs, the underside of the digits themselves showing a naked or nearly naked streak.

The *rhinarium* is always large and moist, there being apparently very little variation with respect to the extent to which the hair of the muzzle encroaches upon it. The upper lip below it is always divided by a narrow moist distensible area, which presents the form of a mere slit when its hairy margins are approximated in the middle line.

The normal tufts of *facial vibrissæ* are always present, but the

\* I use this term indifferently for the main pad of both fore and hind feet.

† P. Z. S. 1914, pp. 478-484. The method adopted in that case of ascertaining the extent of the web by cutting the hairs short has been followed in the present communication dealing with the feet of the wild species of Canidæ and with the Ursidæ. The figures represent the paws with the hairs cut and the digits distended.

vibrissæ vary in length and number according to the species. The interramal tuft is placed nearly in a vertical line with the corner of the mouth when closed. As in most Fissiped Carnivores, there are two genal tufts, one behind the corner of the mouth, nearly in a vertical line beneath the posterior canthus of the eye, the other usually much higher up the cheek and farther back.

The genera of Canidæ hitherto established and admitted rest mainly upon cranial and dental characters.

*Speothos venaticus* Lund.

(Text-fig. 1, A, B.)

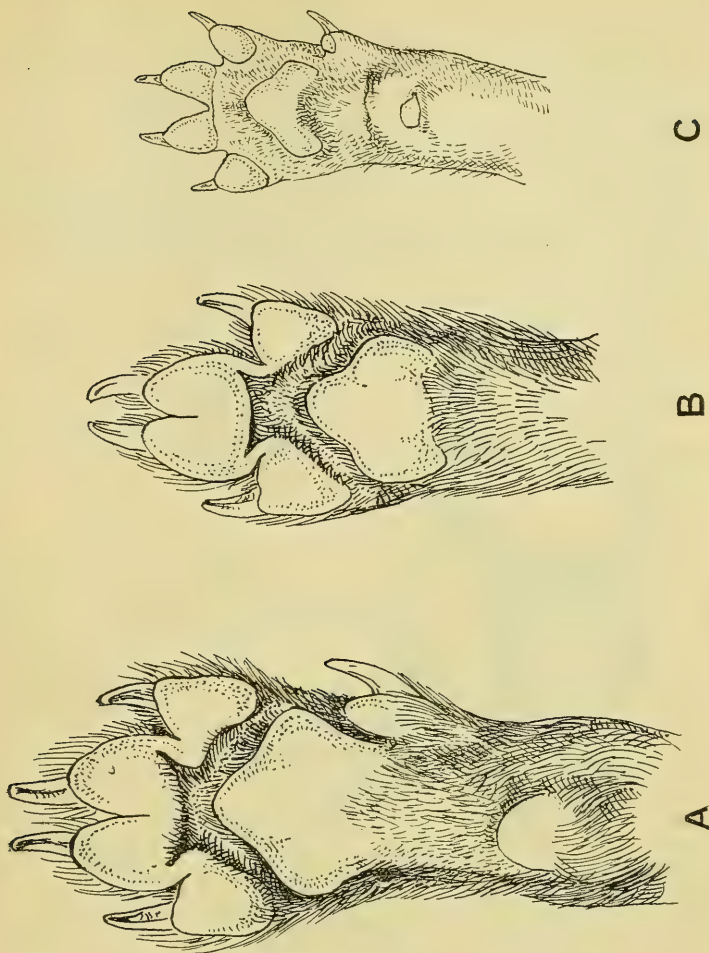
The feet of this rare dog, of which I have only been able to see dried skins, were figured by Flower (P. Z. S. 1880, p. 70), who dismissed them with a mere reference, and this figure was reproduced by Mivart in his 'Monograph of the Canidæ' (p. xv.) to illustrate the structure of the feet characteristic of that family. As a matter of fact, the feet differ from those of all other genera of the Canidæ in two very important particulars, namely, the extensive basal fusion of the third and fourth digital pads of both the front and hind feet, and the approximation of the digital pad of the first digit of the fore foot to the inner proximal angle of the plantar pad. Moreover, the area between the large plantar and the carpal pads of the fore foot is somewhat scantily hairy, especially externally, where a nearly naked strip of integument passes from pad to pad, and the edges of the interdigital integument connecting the second and third and the fourth and fifth digits is naked on both the anterior and the posterior paws, and the area between the digital and plantar pads appears to be sparsely covered with short hairs\*.

From its low position, the first digit, it seems, must reach the ground when the animal is standing in the normal position, especially if the soil be soft. Coupled with the scantiness of the hairy clothing of the area above or behind the plantar pad, this suggests that *Speothos* is more plantigrade than any other existing dog; and it may be recorded in this connection that the mother of a specimen sent to the Gardens in 1879 (P. Z. S. 1879, p. 664) was killed in a creek and that two of the skins in the British Museum are labelled "Shot while running along creek."

If this dog habitually haunts the borders of streams, its plantigrade and scantily hairy feet must be an advantage for progression on sandy or muddy banks. It appears to me to be impossible

\* Except for the forward position of the first digit and the fusion of the third and fourth digital pads in the fore foot, Flower's figure does not show these features well, and it is noticeable that the third and fourth digital pads on the hind foot are represented as separated throughout. The shape of the pads too and the median position of the carpal pad throw doubt upon the reliability of the figure. Hence it may be that the very marked asymmetry between the second and fifth digits on both feet is also exaggerated. But since the figure was taken from a fresh example that point may be correct. If so, it is full of interest; but on dried skins I cannot find convincing evidence that the second digit is so far in advance of the fifth as Flower's figure indicates.

Text-figure 1.



A. Right fore foot of *Speothos venaticus*, from dried skin.  
 B. Right hind foot of same.  
 C. Right fore foot of newly-born cub of *Canis pallipes*, showing the low position of the pollex.

to decide whether the peculiarity of the feet in the matter of the low position of the first digit and carpal pad is a secondarily acquired adaptation to conditions or whether it is a retained primitive character. I incline to the latter opinion, because these peculiarities are present in the newly born pups of species of dogs with normal feet when adult (text-fig. 1, C)\*.

\* In Lund's original figure of *Sp. venaticus* (Kongl. Danske Vid. Selsk. xi. pl. 61, 1845) the first digit is shown in its correct position, but there is a broad web between the remaining four, giving a palmate appearance to the spread paw, which is certainly inaccurate so far as the third and fourth digits are concerned.

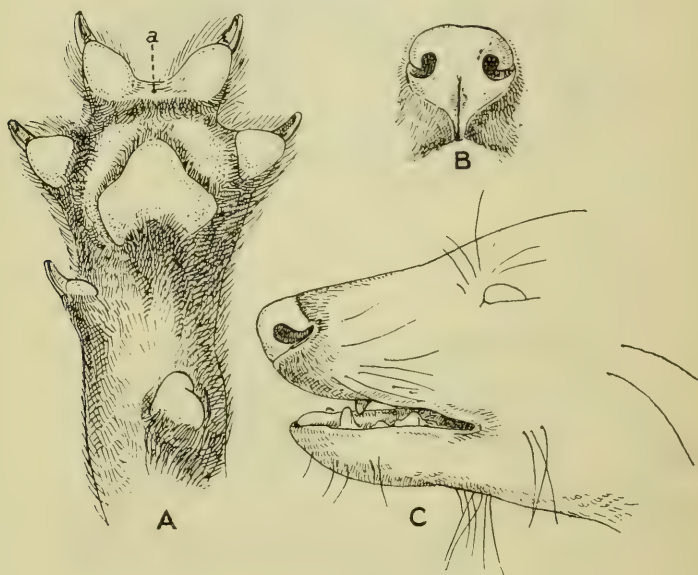
*Cuon primævus* Hodgs.

(Text-fig. 2.)

Apart from Blanford's brief reference to the feet of this species, which he described as having "long hair between the foot-pads," I am not acquainted with any description of them.

I have only seen the feet of two puppies, about four months old. In the relative positions of the carpal and plantar pads and the pad of the first digit, the fore foot resembles that of *Canis anthus* tolerably closely, but the carpal pad is longer and more prominent. Marked differences are noticeable in connection

Text-figure 2.

*Cuon primævus*.

- A. Left fore foot.
- B. Rhinarium from the front.
- C. Side view of face, showing vibrissæ and rhinarium.

with the four main digits. The third and fourth are widely separable, the space between them when distended being equal to that between the second and third and the fourth and fifth. The edge of the web joining them is smooth and not sharply differentiated from them by the hairy covering seen in most species of *Canidæ*. The edge of the web between the second and third and fourth and fifth digits, is not naked and forms a tolerably evenly curved line. The greater part of the sole between the four digital pads and the broadly cordate plantar pad is

scantly hairy, but laterally, close to the proximal margins of the pads and behind the naked rim above described, the hair grows in the form of a long fringe. This combination of features is only found in one other dog that I have examined, namely, *Lycaon pictus*.

Similar features are presented by the hind foot, which, however, is thinner and longer than the fore foot, the third and fourth toes being more prominent and less widely separable and the plantar pad narrower.

The *rhinarium* is bluntly rounded in profile view. Its inferior edge seen from the front is strongly angular, the margin below the nostrils being deep anteriorly and narrow and shallow posteriorly beneath the slit; the nostrils are smallish and widely spaced, and the median groove does not extend up between them.

The *facial vibrissæ* are normal in position and of moderate length, and in the specimen examined the superior genal tuft consisted of two unusually widely spaced bristles.

*Lycaon pictus* Temm.

(Text-fig. 3.)

A single example of *L. pictus sharicus* examined.

The main peculiarity about the feet of this dog, namely, the suppression of the first digit of the fore foot, is well known, but I am not aware that other characters have been recorded.

In one feature at least the fore foot recalls that of *Vulpes vulpes*, namely, in the length and narrowness of the area between the plantar and carpal pads, but here the resemblance ceases, for both these pads are large, as in *Canis*.

The paw itself is strikingly like that of *Cuon*, except that the digits are longer. Very suggestive of kinship between the two genera are the equality in the spacing of the four toes, due to the comparatively wide separation between the third and fourth digits, the nakedness of the edge of the web which joins these two digits together, and the great length of the hairs fringing the proximal margin of the digital pads, and the scantiness of the hairs clothing the sole between the plantar pad and these fringes.

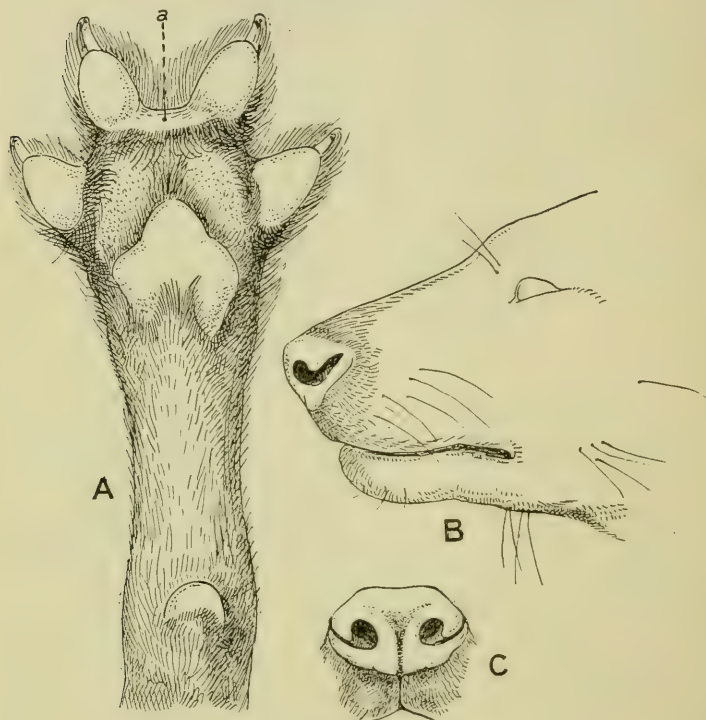
The hind foot is like the front, but is narrower and not so widely splayed.

The chief interest attaching to the feet of *Lycaon* is their likeness in the particulars mentioned to those of *Cuon*, especially as kinship between these two has been suggested on other grounds.

The *rhinarium* is large and wide, rounded anteriorly in profile view; its upper and lower edges parallel and transverse when seen from the front, the inferior edge sinuous and without any marked median inferior prolongation. The nostrils are large, rounded, and somewhat widely separated, the posterior slit of the nostril is bordered below at its posterior end by a thick area of

moist black integument; a somewhat deep median groove extends between the nostrils upwards from the cleft of the upper lip. This rhinarium is very different from that of *Cuon* and the other species and genera of *Canidæ* examined.

Text-figure 3.

*Lycaon pictus.*

- A. Left fore foot. *a*. Naked margin of web joining third and fourth toes.  
 B. Lateral view of face, showing rhinarium and vibrissæ.  
 C. Rhinarium from the front.

*Facial vibrissæ* short and not numerous, except that the interramal and inferior genal tufts, which are normal in position, consist of about four bristles each. The superior genal, consisting of one bristle only, is set much lower than in other *Canidæ*.

*Canis anthus* Linn.

(Text-fig. 4, A, B.)

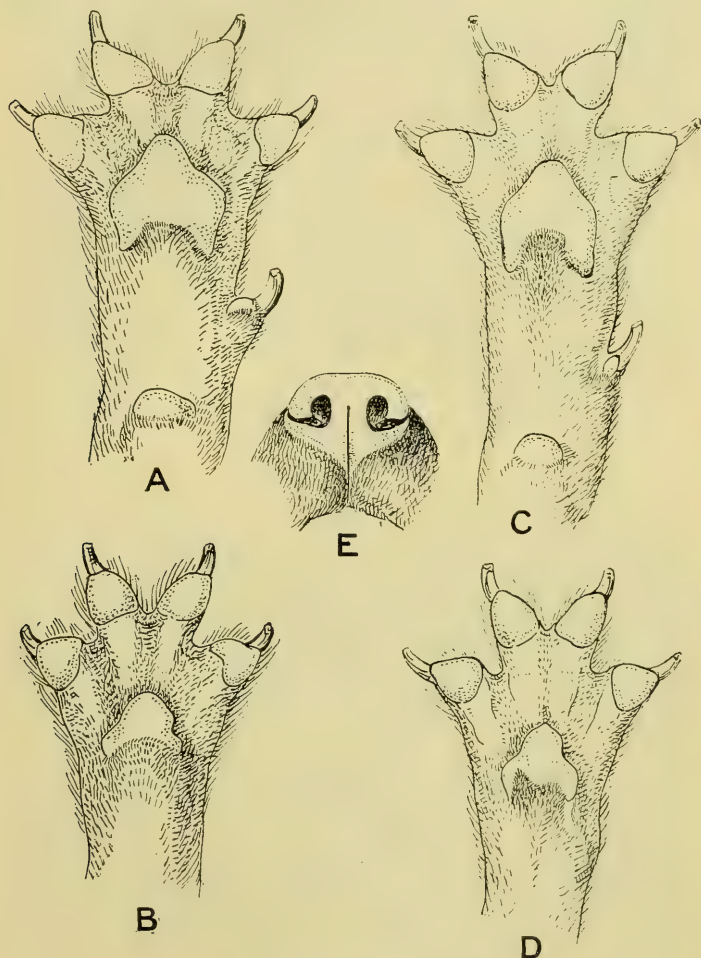
A single example of this Jackal from Morocco.

Fore feet short, especially the third and fourth digits, which

are somewhat tightly tied together, the distance between them much less than that which separates them from the second and fifth respectively. Digital pads moderately large; plantar pad large, both long and wide. Carpal pad large, wider than long.

Hind foot with digits less widely spread than those of front foot, plantar pad much smaller both in width and length.

Text-figure 4.



*Canis anthus* and *C. mesomelas*.

- A. Right fore foot of *Canis anthus*.      C. Right fore foot of *Canis mesomelas*.  
 B. Right hind foot of same.              D. Right hind foot of same.  
 E. Anterior view of rhinarium of *C. mesomelas*.

*Canis mesomelas* Schreb.

(Text-fig. 4, C-E.)

The fore foot of this species is considerably more "foxy" in form than that of *Canis anthus*. The area between the carpal and plantar pads is longer and narrower, the carpal pad is smaller, the plantar pad is narrower and more overgrown with hairs in the middle behind; the area between the plantar pad and the notch between the third and fourth digits is longer, the pads of these digits are tied more tightly together, and the edge of the web between them and the lateral digits is more deeply emarginate.

The hind foot differs from the fore foot in the smallness of the plantar pad and in the still deeper emargination of the edge of the lateral web.

The *rhinarium* is acutely rounded anteriorly in profile; from the front view its upper edge is straight with obtusely rounded angles, and its lower edge acutely angled mesially with obliquely sloping sides, the area beneath the nostrils in front being somewhat shallow and becoming progressively shallower laterally and posteriorly beneath the narial slit.

The *facial vibrissæ* are normal in position and moderately long (see *supra*, p. 901).

*Cerdocyon microtis* Selater.

(Text-fig. 5.)

= *Canis sclateri* Allen.

A single specimen from the Amazons.

Fore feet longer and more loosely webbed than in *C. anthus*, the third and fourth digits joined by a wider web, the distance between them only a little less than that between the second and third and fourth and fifth. Plantar pad large, but rather smaller relatively than in *C. anthus*, its median lobe wider and rounder. Carpal pad high up, very small, and conical. Claws short.

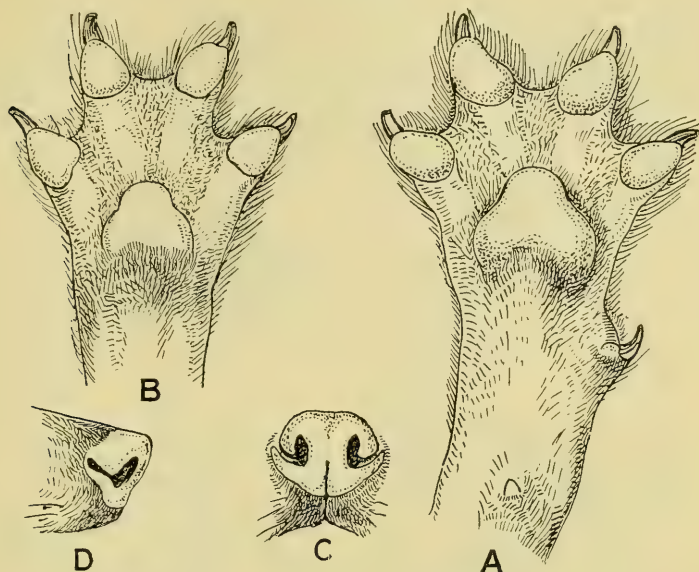
Hind feet longer and narrower than fore feet and with smaller plantar pad, the posterior borders of the pad not deeply emarginate. Hairs between the pads thick, but not specially long.

The *rhinarium* is nearly rectangular anteriorly in profile view. Seen from the front its upper edge is straight and transverse with rather widely rounded angles; its inferior edge is strongly and tolerably evenly convex, owing to the great depth of the portion below the nostrils in front, the portion below the slit of the nostrils behind narrow; hairy area of the lip below the rhinarium shallow, its median slit continued upwards on to the rhinarium as a groove which ascends a little higher than the inferior rim of the nostrils.

The *facial vibrissæ* moderately long—shorter, that is to say, than in *C. mesomelas*, *Ps. gracilis*, and the species of *Vulpes*; normal in position, except that the superior genal tuft, consisting of two

bristles, is set unusually high, nearly on a level with the posterior canthus of the eye.

Text-figure 5.



*Cerdocyon microtis.*

A. Right fore foot.  
B. Right hind foot.

C. Rhinarium from the front.  
D. Rhinarium from the side.

Points to be noticed in connection with this species, apart from the remarkably small size of the ears, which are only  $2\frac{1}{4}$  inches (56 mm.) long\*, are the comparatively wide and nearly even spacing of the digital pads when stretched, the very small size of the carpal and pollical pads, the depth of the rhinarium below the nostrils in front, and the high position of the superior genal vibrissæ.

\* Most of the South American dogs have the ears as long relatively as in typical foxes (*Vulpes vulpes*), which about equal *Cerdocyon microtis* in size and have a skull of about the same length. But, according to Miller, the ears of *V. vulpes* range from 82 to 98 mm.

The cæcum in this example of *C. microtis* was short and uncoiled as recorded by Garrod of *C. cancrivorus* (= *C. thous*), and there is very little doubt that these two species are tolerably closely related. On the other hand, in the specimen of *Ps. gracilis* from Cordova and in an example of *Ps. azaricus* from Mar del Plata, the cæcum was longer and coiled, as described by Garrod of *C. antarcticus*. There are discrepancies in the accounts of the cæcum of *C. azaræ*, Mivart stating it to be straight and Garrod stating it to be coiled. The name *azaræ*, however, has been given to at least two distinct species, one belonging to the *thous*- or *cancrivorus*-group and another to the *culpæus*-group of South American dogs (see Thomas, Ann. Mag. Nat. Hist. (8) vol. xiii. p. 345, 1914). No doubt, Mivart and Garrod had different species under examination, and that Mivart's determination was probably correct may be surmised from the fact that true *azaræ* belongs to the *thous*-group.

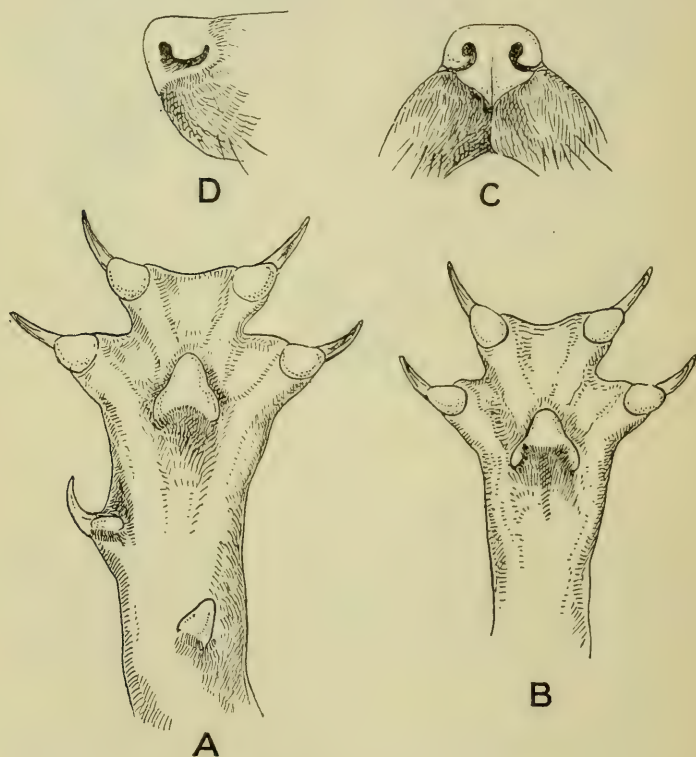
*Pseudalopex gracilis* Burm.?\*

(Text-fig. 6.)

A half-grown specimen of this or an allied species of the *culpæus*-group from Cordova.

Feet long, the small conical carpal pad high above the plantar pad, the pad of the first digit about on a level with the mid-point

Text-figure 6.

*Pseudalopex gracilis*?

A. Left fore foot.  
B. Left hind foot.

C. Rhinarium from the front.  
D. Rhinarium from the side.

between the two. Plantar pad long as compared with its width, narrowly cordate with deeply emarginate posterior border. The digits moderately long, with small pads and unusually distensible,

\* Typical *gracilis* came from Mendoza. Hence the determination of this young individual is a little uncertain.

so that the foot is extraordinarily wide when spread to the fullest extent, the third and fourth capable of being separated until the inner edges of the pads are in a transverse, almost straight, line with the border of the web connecting them which is only lightly emarginate, the width of this web about twice the length of one of the pads and exceeding the distance between the pads of the second and third or fourth and fifth digits. Claws long and slender. The hairs on the lower surface of the foot abundant, silky, and long, completely concealing the pads when undisturbed.

Hind foot very like the fore foot, but smaller, the posterior portion of the plantar pad more overgrown with hairs.

The *rhinarium* is rectangularly rounded in front in profile; from the front view its upper edge is wide and straight with nearly rectangularly rounded angles, its inferior border is mesially angular with obliquely sloping, slightly sinuous sides, the area below the nostrils being moderately deep in front and narrow posteriorly below the slit; the hairy area of the lower lip below the rhinarium in front is moderately deep and the cleft is continued upwards as a shallow groove between the nostrils.

The *facial vibrissæ* are long and abundant and normal in position, about six superciliaries, three interramals, and three to each of the genal tufts. In an example of *Ps. azaricus* from Mar del Plata, the vibrissæ resemble those of the species above identified as *Ps. gracilis*.

The feet of *Ps. gracilis* suggest adaptation to desert conditions, the spread of the digits and the thick hairy clothing preventing sinking in the sand.

It will be interesting to see in the future to what extent the feet of the other fox-like South American dogs, such as *Ps. culpæus*, conform to this type, which differs so widely from that of some of the true foxes of the Old World, like *Vulpes* and *Otocyon*.

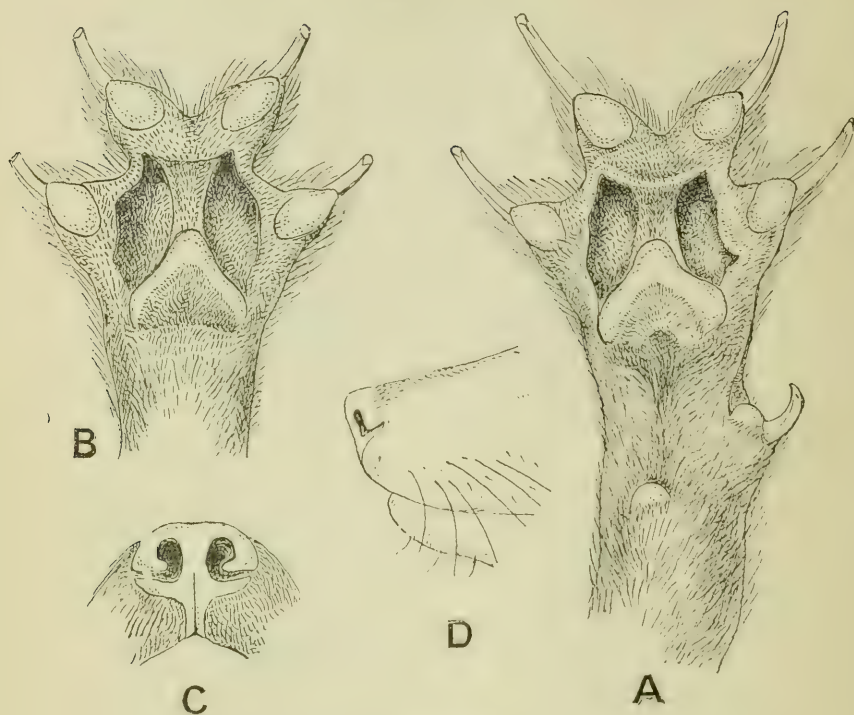
#### *Alopex lagopus.*

(Text-fig. 7.)

A single old female specimen of *A. lagopus spitzbergensis*.

The feet differ from those of all the species of Canidæ examined in the presence of a distinct thickish ridge of integument, passing forwards from the median lobe of the plantar pad to the area behind the point of junction of the third and fourth digits, and dividing the glandular depression between the digital and plantar pads into right and left portions. Moreover, the area of the integument on the proximal side of the digital pads is thickened and cushion-like, not gradually sloped away, so that the partially divided depression is bordered in front and laterally by elevated walls, making it appear deeper than in other species. The median longitudinal ridge of skin is not so high as the plantar pad and as the thickening behind the third and fourth

## Text-figure 7.

*Alopex lagopus.*

A. Right fore foot.  
B. Right hind foot.

C. Rhinarium from the front.  
D. Rhinarium from the side.

digits, and, like the thickenings in question, it is clothed with longish hairs\*.

The feet are shorter and more "dog-like" than in *Vulpes* and *Otocyon*, owing mainly to the third and fourth toes being shorter and a little more widely separable. The digital pads are small and the plantar pad is a little wider than in *Vulpes* and more overgrown posteriorly, so that it appears more deeply hollowed out. The carpal pad is nearer the plantar pad, and is small and irregularly semicircular in outline. Claws very long.

The *rhinarium* in profile view is nearly rectangularly pointed, and much shorter than in any other species examined. From the front view the summit is mesially nearly flat with widely-rounded angles; the inferior edge is not strongly angled, the

\* In the specimen examined, an old female which had been over ten years in the Gardens, the hair on the integumental thickenings was worn off by walking on concrete. But the outline of the digital pads could be distinguished by their scaly pattern, the thickenings being pitted with hair-follicles.

nostrils are large and separated by a very narrow septum, and the groove from the upper lip extends upwards to a point just above the inferior border of the nostrils.

The *vibrissæ* are normal in position, and the mystacial and submental bristles are shorter than in *Vulpes* or *Canis mesomelas*.

Until Miller published his 'Catalogue of the Mammals of Western Europe,' the Arctic fox was not regarded as generically distinct from *Vulpes*, although Kaup and, later, Gray had applied generic names to it, because of the unsatisfactory nature of the characters by which it was distinguished. It cannot be claimed that the diagnostic features employed by Miller are of great value, as he himself seems prepared to admit. Most of them are cranial \*, the only external feature mentioned being the shorter and more rounded ear. If such characters, however, be used for distinguishing "Alopécoid" genera, it will be necessary to give generic status to nearly every species of fox—using "species" in its old sense. Judged, however, by its feet, the Arctic fox is quite distinguishable generically from *Vulpes vulpes* and *bengalensis* and from *Otocyon*, and the same may be said of the rhinarium †.

In the extent of the area of the sole applied to the ground the feet of *Alopex lagopus* show superficial resemblance to those of *Speothos venaticus*, and a comparison between the two species suggests that the structural modification described as fusion of the pads in the latter is due to the nakedness of the integumental cushions behind the pads. But since in *Speothos* the naked areas regarded as pads are granular throughout, and show no trace of hair-follicles like the thickened integument behind the pads in *Alopex*, the view put forward in this paper, that the pads of *Speothos* are enlarged and fused, appears to be correct.

*Vulpes vulpes* Linn.

(Text-fig. 8, A.)

Feet long and narrow with comparatively small pads and long claws. Carpal pad small and set high above the plantar pad; and the digital pad of the first digit (pollex) above the middle of the area between the carpal and plantar pads.

Plantar pad moderately wide, but subcrenate in form, owing to the encroachment of the hair over its median portion posteriorly. Third and fourth digits especially long and tied together by a narrow web, so that the interval between them, when extended, is much less than the interval between the second

\* One feature mentioned needs restating. It is said that the interorbital region of the skull is more elevated than in *Vulpes*, owing to greater inflation of the frontal sinuses. As a matter of fact, the frontal sinuses, as Huxley pointed out, are undeveloped, as in other "Alopécoid" skulls, the inflation in question being caused by the upward extension of the nasal passages.

† The caudal gland in the specimen examined was larger than in any species of Canidæ that I have looked at. It was a hairless patch of very thick glandular skin about 25 mm. long and one-third longer than wide. There was no underfur mixed with the hairs surrounding it; and, like the feet, it gave out a strong "foxy" smell.

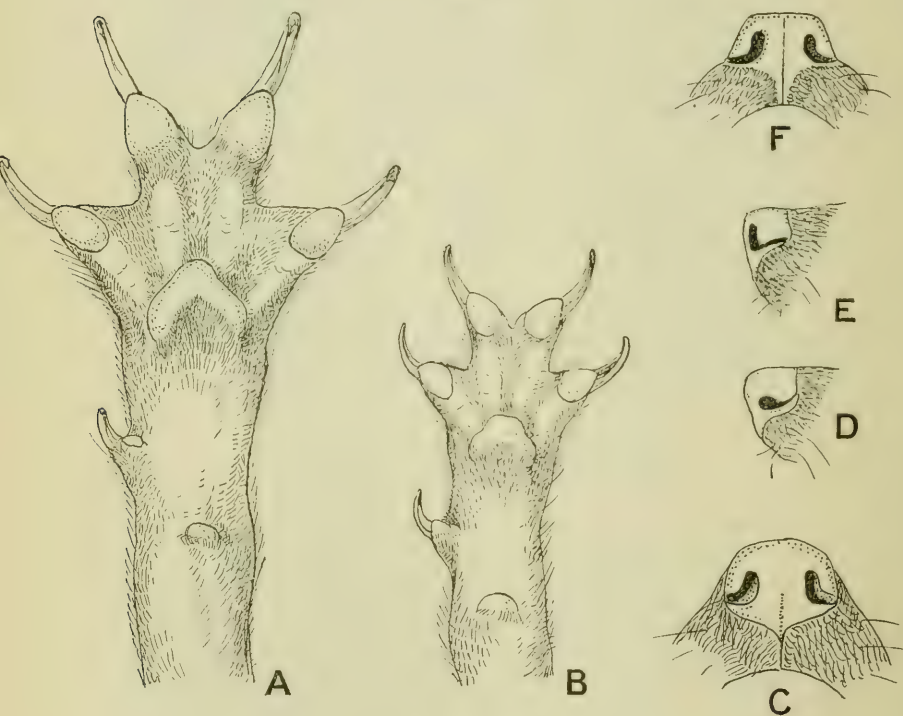
and third and the third and fourth digits. The length of the four digits makes the edge of the web connecting the median and lateral toes appear widely scooped out. The claws are long and the hair clothing the area between the digital and plantar pads is thick, but not long\*.

*Vulpes bengalensis* Shaw.

(Text-fig. 8, B-D.)

The feet are similar in a general way to those of *V. vulpes*, but the third and fourth digits are, if anything, relatively longer

Text-figure 8.



*Vulpes and Otocyon.*

- |  |  |
|--|--|
| A. Left fore foot of <i>Vulpes vulpes</i> .      | D. Rhinarium of same, from the side.                         |
| B. Left fore foot of <i>Vulpes bengalensis</i> . | E. Rhinarium of <i>Otocyon megalotis</i> ,<br>from the side. |
| C. Rhinarium of same, from the front.            | F. The same, from the front.                                 |

\* The hairiness of the soles of the feet may vary seasonally in this species, as it does in some of the northern Canidae. Very likely, too, variation in this respect will be found between geographical races of *V. vulpes*.

and the second and fifth shorter. The carpal pad is relatively larger, the posterior region of the plantar pad is less overgrown with hair, and the hairs arising just behind the digital pads are exceedingly long and project forwards beneath the pads as far as the tip of the long slender claws.

The *rhinarium* is slightly acutely rounded in profile view anteriorly; from the front its upper edge is tolerably evenly curved and its inferior border only slightly angled mesially, the area below the nostril being moderately deep in front and narrow below the slit posteriorly.

The *facial vibrissæ* are long and normal in position.

*Otocyon megalotis* Desm.

(Text-fig. 8, E, F.)

In all essential respects the feet of this fox, accorded generic rank mainly by reason of its abnormal dentition, agree with those of *Vulpes vulpes* and *bengalensis*, although the third and fourth digits are a little shorter. The median lobe of the plantar pad is a little more prominent, especially as compared with that of *V. bengalensis*, and its posterior border is emarginate by the growth of hairs as in that species. The carpal pad is very small.

The *rhinarium* is slightly elevated above and rectangularly rounded anteriorly in profile view; seen from the front its upper edge is straight with obtusely rounded angles and its lower edge is angular, the portion below the nostrils being shallow and very narrow laterally and posteriorly below the slit.

The *facial vibrissæ* are normal in position and moderately long.

CONCLUSION.

Although only a few species of Canidæ, compared with the numbers known, have been described in the foregoing pages, they fortunately represent the main groups of generic or subgeneric rank into which the family has been divided. It is probable therefore, I think, that the extremes of variation in the structure of the feet, in the shape of the rhinarium, and the disposition of the vibrissæ have been observed.

It does not appear to me to be likely that the broad distinction between *Speothilos* and the rest will be lessened by the examination of other species—and probably *Lycæon* and *Cuon*, and possibly *Alopex*, will also remain isolated; but it would be rash to assume in the present state of our knowledge that the differences in foot-structure between the species recorded under *Pseudalopex*, *Cerdocyon*, *Canis*, and *Vulpes* will hold good in all cases when the species related to them come to hand for examination. That, however, remains to be seen.

In the meantime, it may be useful to tabulate the results so far achieved to show briefly how the species may be grouped, and to draw attention to the more salient characters presented by the feet. In the following table, however, I have only made

use of the fore feet, partly in the interests of brevity, partly because they supply the best characters, and partly because the features presented by the vibrissæ and rhinarium call for verification on fresh material, which is unavailable at the present time:—

- a. Pad of pollex set low down close to the posterior lateral angle of the plantar pad; pads of third and fourth digits basally united; edge of web between median and lateral digits naked; area between digital and plantar pads and between carpal and plantar pads scantily covered with short hair ..... *Speothos venaticus*.
- a'. Pad of pollex, when present, high above plantar pad; pads of third and fourth digits separated; edge of webs joining the median with the lateral digits hairy; area between digital pads and plantar pad and between the latter and the carpal pad mostly thickly hairy.
- b. Edge of web joining third and fourth digits naked, forming a definite hairless band; a long fringe rising behind this and extending round the periphery of the foot behind the digital pads.
- c. Pollex suppressed, feet long, carpal pad high above plantar pad ..... *Lycaon pictus*.
- c'. Pollex retained; feet shorter, carpal pad moderately high above plantar pad..... *Canis primævus*.
- b'. Edge of web between third and fourth digits hairy.
- d. Glandular depression between pads undivided; integument proximal to the pads not specially thickened.
- e. Third and fourth digits exceedingly widely separable, the edge of their web when stretched forming a straight line about twice the length of the pads of either digit; plantar pad long and narrow ..... *Pseudalopex gracilis*.
- e'. Third and fourth digits much less widely separable, the edge of the web between them emarginate when stretched and less than the length of the pad of either digit.
- f. Plantar pad large, its width exceeding the length between its median lobe and the margin of the web between the shorter third and fourth digits; claws short.
- g. Carpal pad very small, third and fourth digits more widely separated, the web joining them, when extended, as wide as that between them and the lateral digits ..... *Cerdocyon microtis*.
- g'. Carpal pad large, third and fourth digits more closely united; the connecting web narrower than that between them and the lateral digits... *Canis anthus, mesomelas* \*.
- f'. Plantar pad small, its width considerably less than the distance between its median lobe and the edge of the narrow web between the long third and fourth digits; claws long ..... *Vulpes vulpes* and *bengalensis*; *Otocyon megalotis*.
- d'. Glandular depression between digital and plantar pads divided by a ridge of thick skin stretching forwards from the median lobe of the plantar pad; integument surrounding proximal portion of digital pads much swollen and cushion-like; feet otherwise almost as under e' ..... *Alopex lagopus*.

The above-given analysis of the characters of the feet of the Canidæ emphasises the distinctness of *Speothos* from the rest of the genera, and does not afford support to the affiliation of *Speothos*

\* The feet of domestic breeds of dogs come under this heading. The feet of some breeds indeed conform very closely to the type seen in *Canis anthus* (see P. Z. S. 1914, pp. 478-484).

with *Cuon* and *Lycaon* in the *Cuon*-group opposed to the *Canis*-group containing *Canis*, *Vulpes*, and *Otocyon* \*.

On the contrary, the distinctness of *Speothos* may, I think, be justifiably expressed by setting the genus aside in a special subfamily, the *Speothoinæ*, the remaining genera being called *Caninæ*.

There is, as yet, no agreement respecting the number of genera into which the Canidæ are divisible, but all recent zoologists are in accord in admitting *Lycaon*, *Cuon*, *Canis*, *Vulpes*, *Otocyon* and probably *Nyctereutes* and *Urocyon*. Both *Vulpes* and *Canis* have been further subdivided into many genera or subgenera. Thomas †, for instance, has recently shown that, apart from *Speothos*, the following South American dogs have been generically named as follows:—*Chrysocyon* for *jubatus*; *Dasiocyon* for *antarcticus*; *Cerdocyon* for *thous* (= *cancrivorius*) and *brasiliensis* (= *azarae*); *Pseudalopex* for *magellanicus*, *azaricus*, etc., and *Lycalopex* for *vetulus*. At present, however, these genera are, I believe, merely nominal, in the sense of being undefined. There will be time enough to discuss their validity when the distinctive features have been ascertained and stated; and the same may be said for such subdivisions of *Vulpes* as *Fennecus* and *Zerda*. Possibly extended study of the feet and other external features may help the settlement of this difficult question.

#### Family URSIDÆ ‡.

The subjoined account of the feet and the noses of the Ursidæ is based upon the examination of examples of the following species that have died in the Gardens, namely, the Polar Bear (*Thalartos maritimus*), the American Black Bear (*Ursus americanus*), the Himalayan Bear (*Tremarctos thibetanus*), and the Sloth Bear (*Melursus ursinus*); and secondly, upon observations on living examples in the Society's menagerie and upon dried skins in the British Museum. The four species in question exhibit the extreme range of variation in the structure of the feet, the Polar Bear and the Sloth Bear being at opposite poles in the matter of modification; and all the other existing species of bears agreeing, apart from minor details, either with *U. americanus* or with *T. thibetanus*.

The general shape of the feet of bears is well known. Measured from the carpus or the tarsus to the tips of the phalanges, they are remarkably short and broad. The five digital pads form a slightly curved line, the second, third, and fourth being nearly on a level and a little in advance of the first and fifth. A short distance behind these pads, and separated from them by a comparatively thin-skinned depression, comes the wide

\* By Matthew and Osborn ('The Age of Mammals,' 1910). I do not, however, know the nature of the evidence on which this classification was based.

† Ann. Mag. Nat. Hist. (8) vol. xiii. p. 352 (1914).

‡ For the generic terms adopted for this family see *infra*, pp. 939-940.

and flattish main or plantar pad\*. Behind the plantar pad of the fore foot there is always one additional carpal pad on the external or ulnar side of the carpus; and on the hind foot there is always a larger or smaller naked area, which may involve the whole of the posterior portion of the sole as far back as the heel. It is mainly, however, in the degree of hairiness of this area behind the plantar pads of both fore and hind feet that the greatest variation is exhibited.

*Feet of the Polar Bear (Thalarcos maritimus).*

(Text-fig. 9, A, B.)

In two newly-born cubs of Polar Bears from Spitzbergen, the digital pads are not webbed, but are separated to the base as in all bears except *Melursus*. The depressed area between them and the very short and wide plantar pad is scantily covered with very short hairs, and the area behind the plantar pad is similarly covered, except for the small external carpal pad on the fore foot and a corresponding, elongated, somewhat piriform, anteriorly pointed, small, flat pad on the sole of the hind foot, which are quite naked.

In our adult living examples the soles of the feet, apart from the digital and plantar pads, the carpal pad, and the corresponding elliptical area on the hind foot, are thickly covered mostly with long hair, except the sole of the hind foot, where the hair is worn short; and in a male specimen a narrow strip of naked skin extends forwards from the naked elliptical area to the plantar pad of the hind foot. The feet, in fact, agree with the description of the feet of the Polar Bear, recently published by G. S. Miller †, who says:—"Fore feet with palmar tubercles and balls of toes essentially as in *U. arctos*, but smaller; pad on hind foot without backward continuation along inner [outer] portion of sole." Since Miller did not detect the little naked pad behind the plantar pad on the hind foot, it is possible that this pad is sometimes, perhaps seasonally, covered with hair. But its presence in this newly-born cub is full of significance.

*Feet of the Black Bear (Ursus americanus).*

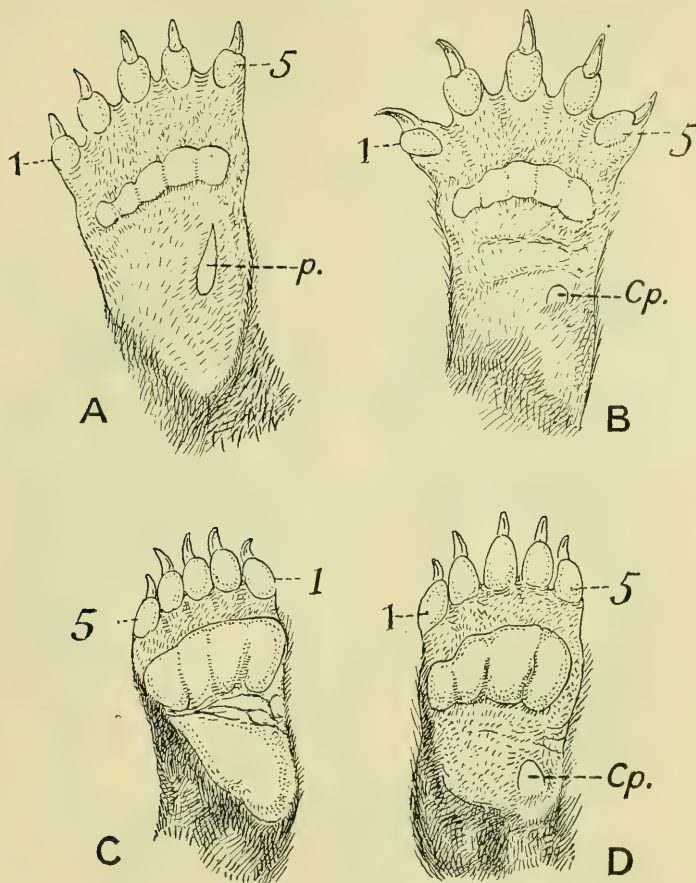
(Text-figs. 10 and 13, D, F.)

The fore feet of an adult male Black Bear from Newfoundland agree in essential points with those of the Polar Bear, that is to say, the digital pads are separated, the depression behind them is covered thickly with long hairs, and the area behind the plantar pad is similarly clothed with hairs, from which the carpal

\* It is the custom sometimes to call the main pad of the fore foot the "palmar" and that of the hind foot the "plantar" pad. But in this paper I have used the term plantar for the main pads of both fore and hind feet.

† Cat. Mamm. Western Europe, p. 298, 1912. In his description of the hind foot of this species, as of *U. arctos*, Miller wrote "inner" for "outer."

Text-figure 9.



Newly-born cubs of Polar Bear (*Thalarectos maritimus*) and of European Brown Bear (*Ursus arctos*).

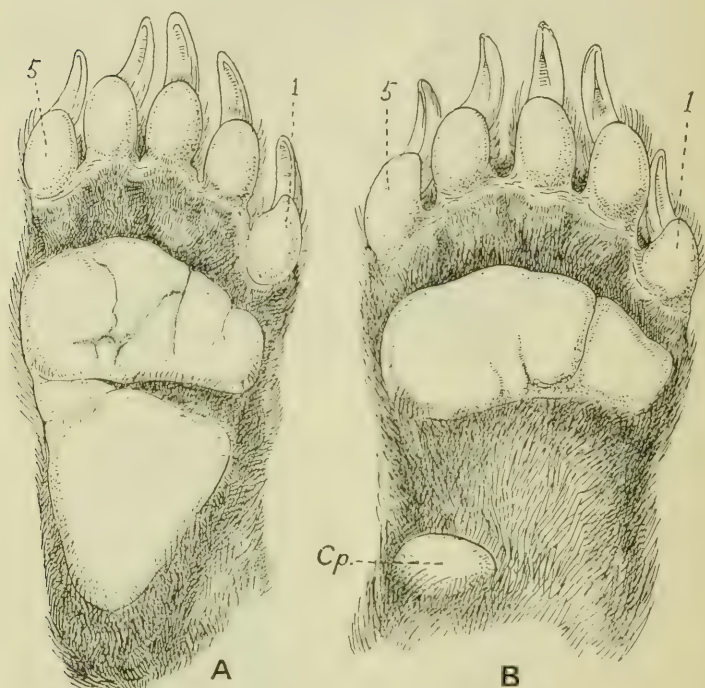
- A. Left hind foot of Polar Bear (*Thalarectos maritimus*), the digits spread.      C. Right hind foot of Brown Bear (*Ursus arctos*).  
 B. Left fore foot of same.      D. Left fore foot of same.

1 and 5, first and fifth digits; *Cp.*, carpal pad; *p.*, pad on sole of hind foot of *T. maritimus*.

pad rises like an island. But this pad, the digital pads, and especially the plantar pad are relatively large. The hind foot, however, is very different, in being mostly naked almost back to the heel. On the inner or hallucal side, however, the hair grows inwards from the edge of the foot for a short distance behind

the plantar pad, filling up the depression which at this point separates this pad from the posterior naked part of the sole.

Text-figure 10.



*Ursus americanus.*

A. Right hind foot.

B. Right fore foot.

1 and 5, first and fifth digits; Cp., carpal pad.

*Feet of the Himalayan Bear (Tremarctos thibetanus).*

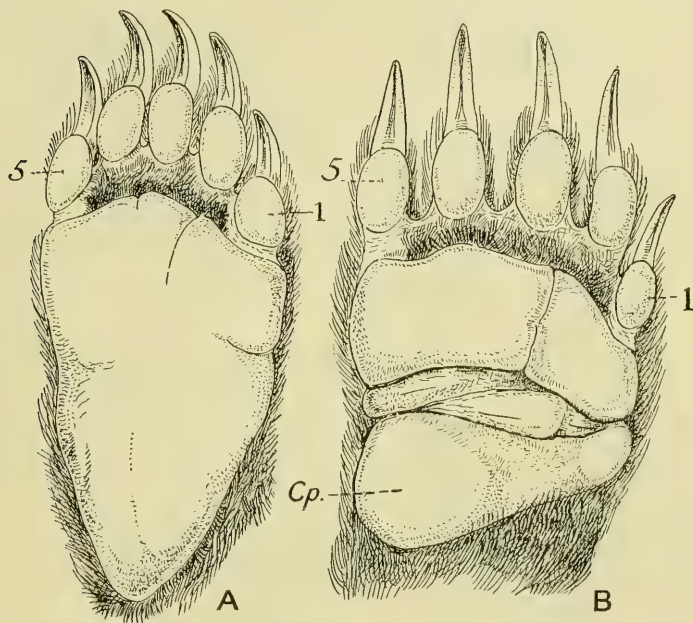
(Text-figs. 11 and 13, C.)

The fore feet differ markedly in one or two points from those of the Black Bear. The area between the digital pads and the plantar pad is hairy only behind the pads of the second, third, and fourth digits; behind the first and fifth of these pads it is naked and the digital pad of the first is smaller and set still farther back, its distal end scarcely reaching the proximal end of that of the second. The plantar pad is large. Behind it there is a naked depression of thinner skin and the carpal region is also wholly naked, the ulnar carpal pad forming a large protuberance and the radial a smaller one. This smooth carpal area

is sharply circumscribed behind by the dense clothing of hair covering the lower side of the leg.

The hind foot broadly resembles that of *U. americanus*, except that the depression behind the digital pads is clothed with hairs in the same way as the fore feet and the hairs from the inner edge do not encroach upon the sole in the depression marking off the plantar pad postero-internally. The tips of the pads of the first and fifth digits slightly overlap the proximal ends of those of the second and fourth respectively.

Text-figure 11.



*Tremarctos thibetanus*.

A. Right hind foot.

B. Right fore foot.

1 and 5, first and fifth digits; Cp., carpal pad.

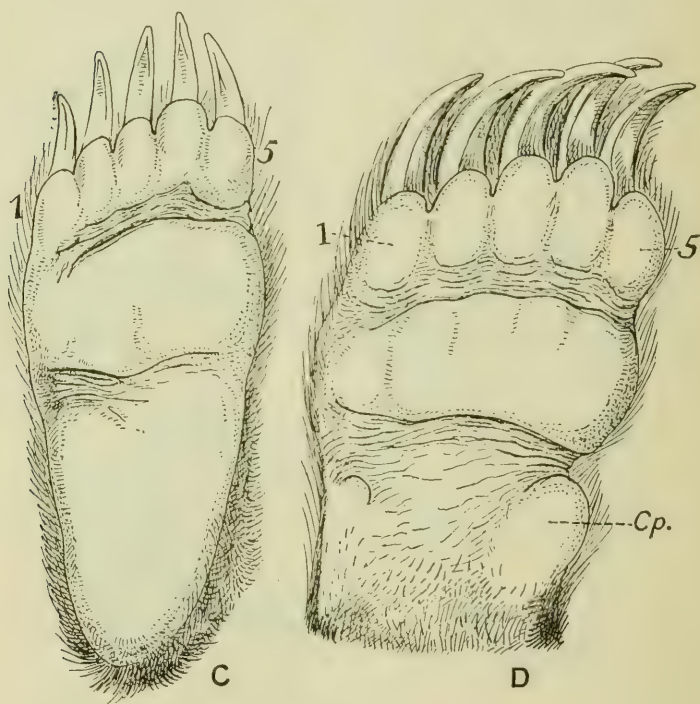
*Feet of the Sloth Bear (Melursus ursinus).*

(Text-figs. 12 & 13, A, E.)

The feet differ from those of all other species of Ursidæ, in that the digital pads are fused almost to their distal ends, so that no hair projects between them from the sides of the digits, and the first and fifth digits are set far forwards as compared, at all events, with *T. thibetanus*. Moreover, the depression behind the the digital pads is quite naked, as Gray pointed out. In the fore feet the carpal area is naked, as in

*T. thibetanus*, but this naked area is not sharply defined behind by a coating of thick hair, but passes insensibly into the skin of the posterior surface of the leg, which inferiorly is scantily clothed with short hairs. The sole of the hind foot is entirely naked, the posterior limit of the plantar pad being marked by a transverse groove, which expands into a shallow depression on the hallucal or inner side.

Text-figure 12.

*Melursus ursinus.*

C. Left hind foot (too narrow for its length).

D. Left fore foot.

1 and 5, first and fifth digits; Cp., carpal pad.

*Feet of other Species of Bears.*

The feet of the Polar Bear and of the Sloth Bear are unique in the family, but those of other species, of which I have only seen dried skins or living specimens, agree in the main with those either of *T. thibetanus* or of *U. americanus*, *U. arctos* and *horribilis* falling into the same category as *U. americanus* and *Helarctos malayanus*, and *T. ornatus* into that of *T. thibetanus*.

G. S. Miller\* describes the feet of the Brown Bear of Western Europe as follows:—"Balls of the digits [of fore feet] large, pad-like . . . first digit with anterior edge of ball extending about to middle of that of second, the interval greater than in the case of the other digit . . . main pad wider than long, covering more than half the surface of the palm, its outer border about twice as long as its inner, its posterior border slightly concave, its inner portion at base of thumb [1st digit] marked off from the rest by a slight furrow; region between main pad and balls of digits densely furred; wrist-pad about as large as ball of digits, near outer ulnar margin of palm, its long diameter transverse; region between wrist-pad and main pad densely furred . . . Hind foot longer than fore foot, pad like that of fore foot, but with a broad backward extension passing along inner [outer] side† nearly or quite to heel; region between pad and balls of toes and at outer [inner] side of backward extension densely furred."

In a newly-born cub of *U. arctos* (text-fig. 9, C, D, p. 931), the area between the digital and plantar pads of both fore and hind feet is scantily covered with very short hairs, the posterior or heel pad of the hind foot is naked, and there is a well-marked depression of wrinkled skin on the inner side of the foot between this pad and the plantar pad. In the fore foot the area behind the plantar pad is scantily clothed with short hairs, and the conical carpal pad is situated near the postero-external portion of this area.

So far as I have been able to examine them, the living bears of this species in the Gardens, namely examples from the White Sea, Caucasus, Himalayas, Behring Sea, and Alaska, have the feet as above described by Miller, except that the entire sole of the hind foot is generally naked, there being usually no extension of the hair behind the plantar pad on the inner side. In some Brown Bears, too, there is a narrow strip of scantily-haired skin extending from the carpal pad to the plantar pad of the fore foot, and sometimes a small naked area marks the position of a radial carpal pad. These points may be worth further investigation from the systematic point of view.

In one of two Grizzly Bears (*U. horribilis*) from Montana, the feet seem to resemble those of our Brown Bears; and Mr. Seton's figure of the paws of the Grizzly show the same conformity to the Brown Bear type.

The chief difference between the feet of *U. americanus*, on the one hand, and *U. arctos* and *horribilis*, on the other, is that in the former the first digit and the carpal pad seem to be set farther back.

*Tremarctos thibetanus* ranges from Baluchistan to Eastern Asia, and is represented in Japan by *T. japonicus*, which is probably

\* Cat. Mamm. Western Europe, p. 287, 1912.

† The sole is continuous along the *outer*, not along the *inner* side of the foot. The hairy ingrowth interrupting the continuity of the sole occurs on the *inner* or hallucal side.

only a subspecies of it. At all events, the feet are the same in the two forms.

Moreover, the feet of the Malayan Bear (*Helarctos malayanus*) agree in all essential respects with those of *T. thibetanus*, except that the hairs in the depression behind the second, third, and fourth digital pads are much fewer in number, the integument being scantily furred, and thus approximating the naked condition of this area seen in *Melursus*. The Andean Bear (*T. ornatus*) also resembles *T. thibetanus* in the structure of its feet, except that the depression behind the digital pads is continuously and thickly hairy, even behind the pads of the first and fifth digits.

### *Structural Adaptation of the Feet to Habits.*

The bionomical reason for the differences in the structure of the feet of existing Ursidæ is obscure. The first thing to note is the rough correspondence between the hairiness and nakedness of the sole and the geographical latitudes inhabited by the species. The hairiest feet of all are found in the Arctic species (*Thalarctos maritimus*), and this feature is always assumed, probably correctly, to be a modification to obviate the likelihood of slipping on ice. But it must also be remembered that the haunts of this bear are treeless, and that this species is unable to climb. South of the range of the Polar Bear come the various races of *Ursus arctos*, of *U. horribilis*, and of *U. americanus*, which have larger pads on the fore and hind feet than in *Thalarctos maritimus* and the greater part, at all events, of the sole of the hind feet naked. Even the northern form of these species, by reason of their hibernation, are never abroad for any length of time when the cold is severe enough to cover the ground for weeks at a time under a continuous sheet of frozen snow. The countries they inhabit are forested, and both the Black and the Brown Bears are known to climb trees. The Grizzly does not climb—at all events, as a rule,—but he probably could do so, if necessary, though, on account of his greater bulk, not with such ease as the Black Bear and smaller representatives of the Brown Bear. Nevertheless, neither the Black Bear nor the Brown Bear seems to be so apt at climbing as the three naked-footed bears of the Old World, namely, the Himalayan, the Malayan, and the Sloth\*; and living examples of these species have an obviously clumsier, more shuffling gait than the northern species, and this awkwardness of movement is due very largely, if not wholly, to the natural inturning of the fore feet.

\* I know nothing of the Andean Bear (*U. ornatus*) in this connection. Of the Himalayan Brown Bear (*U. arctos isabellinus*), Blanford says:—"They can climb trees, but, in the Himalayas, at all events, rarely do so"; of the Himalayan Bear, "it is more in the habit of climbing trees for fruit [than the Brown Bear], and is not infrequently found in fruit trees," and of the Malayan species "this bear is a purely forest animal and an admirable climber," while his account of the Sloth Bear contains many references to its scansorial habits.

This characteristic of the limbs is more marked in the Malayan and the Sloth Bear than in the Himalayan, which in this, as in other respects, comes nearer the group of bears typified by *U. arctos*. I think it probable that the nakedness of the carpal area of the underside of the fore foot in those three species as well as the inturning of the paws are adaptations to climbing, because naked roughish integument will give a better hold on bark than integument covered with hairs, and during the ascent or backward descent of a vertical tree-trunk—bears always climb down rear end foremost—the upward turn of the fore paws gives the claws a securer grip on the bark, because their points are set at right angles to the axis of the trunk, without interfering with the clasping action of the limb.

### *Noses of Bears.*

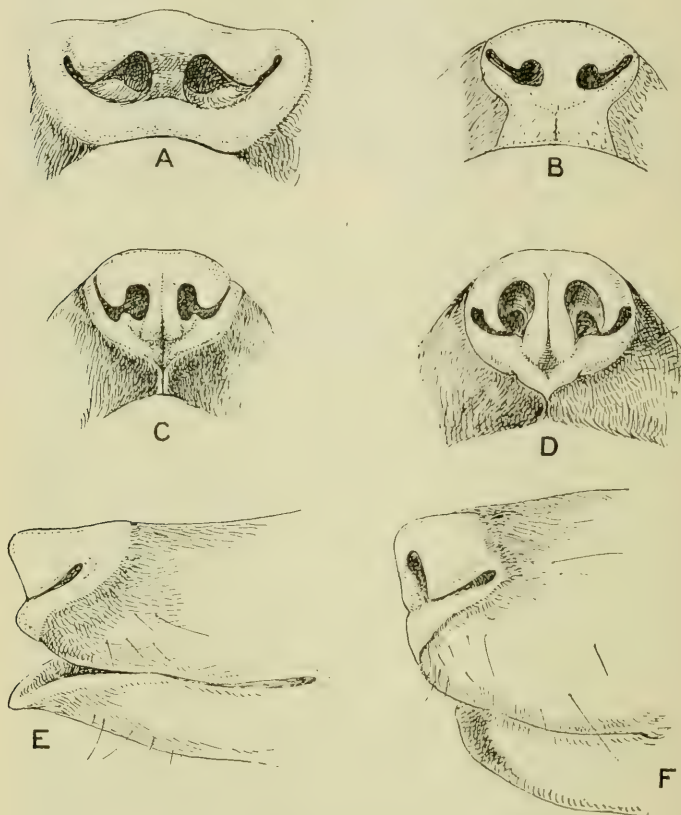
The rhinarium of Bears is always large and naked, and is circumscribed above and at the sides by the short hairs of the muzzle and upper lips. Usually the hair on the summit of the muzzle forms nearly a straight line, passing from the posterior notch of one nostril to that of the other; and beneath the rhinarium the hairs of the upper lip extend almost or quite to the middle line, leaving at most a narrow strip of naked integument below the rhinarium. I have not been able to examine sufficiently closely a large enough number of specimens to show the variation in width to which this strip of integument is liable in *Ursus arctos*, *horribilis*, *americanus*, *Tremarctos thibetanus*, *ornatus*, but in all these species, as in *Thalarcos maritimus*, it is at most a few millimetres wide, narrower, that is to say, than the median area of the rhinarium between the inner edges of the nostrils.

But in the Sloth Bear (*Melursus*) the rhinarium is very large. Dorsally it extends forwards so as to overhang the nostrils and backwards some distance behind the posterior end of the slit of the nostrils. It is also much wider beneath the slit laterally and there is a very wide median area of moist skin annexed to the rhinarium on the upper lip. The only bear possessing a rhinarium approaching that of *Melursus* in relative size is *Helarctos malayanus*, which, in this respect, is intermediate between *Tremarctos thibetanus* and *Melursus ursinus*. In both these species the greater size of the rhinarium and of the moist naked area below it, is associated with the mobility of the snout and upper lip, which is a marked feature in *Helarctos malayanus* and reaches an extreme in *Melursus ursinus*.

The *facial vibrissæ* of Bears are reduced in number and length, as compared with those of most other Carnivores. A few buccal and superciliary bristles are retained, but the genals and interramals appear to be suppressed as a rule. The genals I did not find in any of the dead specimens examined, but in the example

of *T. thibetanus* the interramal tuft was represented by a single longish hair.

Text-figure 13.



Rhinaria of Bears.

- |    |                                    |   |
|----|------------------------------------|---|
| A. | Anterior view of rhinarium of      | <i>Melursus ursinus</i> .                       |
| B. | Ditto                              | <i>Helarctos malayanus</i> (from a dried skin). |
| C. | Ditto                              | <i>Tremarctos thibetanus</i> .                  |
| D. | Ditto                              | <i>Ursus americanus</i> .                       |
| E. | Side view of lips and rhinarium of | <i>Melursus ursinus</i> .                       |
| F. | Ditto                              | <i>Ursus americanus</i> .                       |

*Systematic Value of the Feet.*

From time to time the Ursidæ have been split up into a considerable number of genera and subgenera, based partly upon external, but mainly upon dental and cranial characters, the only well-marked species which has never apparently received a special

title, even from Gray, being *U. thibetanus*. For instance, we have *Thalarcos* (usually altered to *Thalassarcos*) for *maritimus*; *Ursus* for *arctos* and its allies, *Danis* for *horribilis*, *Euarctos* for *americanus*, *Tremarctos* for *ornatus*, *Helarctos* for *malayanus*, and *Melursus* for *ursinus*. *Melursus* seems to be admitted on all hands as valid; but probably no two existing zoologists could be found to agree about the others, though a majority would most likely favour the severance of *Thalarcos* from *Ursus*. Flower and Lydekker ('Mammalia Living and Extinct,' pp. 558-560, 1891), for example, gave full generic value to *Melursus* and to *Ursus*, and divided the latter into the *Thalarcetine* section for *maritimus*; the *Ursine* for *arctos*, *horribilis*, *americanus*, *thibetanus*, *ornatus* and their allies, and the *Helarctine* section for *malayanus*. Max Weber (Die Säug. p. 535, 1904) admitted *Ursus*, with *Thalarcos* as a subgenus, *Helarctos* and *Melursus*, but only diagnosed the latter; and Beddard ('Mammalia,' pp. 442-443) allowed *Ursus* and *Melursus*, dismissing *Thalarcos* as a "quite unnecessary" genus.

Trouessart (Cat. Mamm. Suppl. pp. 178-182, 1904) followed Flower and Lydekker in the main, but gave subgeneric value to the sections of *Ursus*, adding *Euarctos* to them, and accorded full generic status to *Tremarctos* for the S. American Bears.

Finally, Matthew and Osborn ('The Age of Mammals,' p. 530, 1910) adopted the four genera, *Ursus* for the Grizzly, Brown, and American Black Bears, and, I presume, for the Himalayan and Malayan as well, *Thalarcos* for the Polar Bear, *Tremarctos* for the Andean or Spectacled Bear, and *Melursus* for the Sloth Bear.

The divergence of opinion with respect to the status of such species as *maritimus*, *americanus*, *ornatus*, and *malayanus*, indicated by these classifications, suggests that the characters used for their elevation to the rank of genera or subgenera cannot be very well marked\*. But in view of the conclusions arising from the facts established in this paper, the one interesting point about which these authors seem to be in accord, differ as they may about the four species just quoted, is that *thibetanus* is inseparable from *Ursus*, even in the most restricted sense assigned to that term.

Beyond stating that the soles of the feet are more hairy in the Polar Bear, the authors above quoted made no systematic use of the extremities, although Gray had previously pointed out some distinguishing features presented by them†. He detected,

\* The classifications of Trouessart and of Osborn & Matthews are, however, mere lists of names, no reasons for the arrangement adopted being given. It would be interesting to know why these authors, alone of those quoted, give full generic value to *ornatus*.

† Considering the wide field covered by his work, J. E. Gray was head and shoulders in front of many of his predecessors and successors as a systematist in the strict sense of the word. One is too apt to allow his mistakes, arising from his curious limitations, to obscure one's regard for the perspicacity he undoubtedly possessed in the detection of structural differences.

for instance, that the area behind the digital pads in the Sloth Bear is naked, whereas it is hairy in others. But he does not appear to have noticed the marked differences presented by the carpal area in the matter of hairiness and nakedness in various species, and his statement that in *Thalassarcos* the "soles of the feet are hairy with a few callous pads, whereas in *Ursus*, *Helarcos*, and *Melursus* they are bald and callous," gives very little idea of the true state of affairs (see Cat. Carn. etc. Mammalia, pp. 217-237, 1869).

Judged by the characters discussed in this paper, the following genera seem to me worthy of admission—*Melursus*, *Helarcos*, *Tremarcos*, *Ursus*, and *Thalarcos*. They may be defined as follows :—

- a. Digital pads fused almost up to their distal ends, depression between them and the plantar pad of both fore and hind feet naked; carpal area of fore paw naked with large rounded external and smaller internal pads; integument of fore leg behind carpal area scantily covered with short hairs; snout highly mobile, rhinarium very large, extending to edge of lip as a broad moist area and overhanging the nostrils above ..... *Melursus*.
- b. Digital pads separated throughout their length, depression between them and the plantar pads more or less hairy; integument behind carpal area thickly covered with hair; snout less mobile, rhinarium smaller and not overhanging the nostrils.
- c. Carpal area as in *Melursus*, naked and furnished with a larger rounded external and a smaller internal pad.
- d. Hair on upper lip not extending beneath the nostrils in front, but leaving a comparatively wide moist median area continuous with the rhinarium above ..... *Helarcos* \*.
- d'. Hair on upper lip extending nearly to middle line and leaving only a narrow naked strip of skin continuous with the rhinarium ..... *Tremarcos*.
- c'. Carpal area behind plantar pad thickly hairy, carpal pads represented by a single rounded eminence on the outer side, as in the Canidæ and Felidæ, and sometimes by a smaller one as well on the inner side; rhinarium approximately as in *Tremarcos*.
- e. Pads large as in the preceding genera; sole of hind foot behind the plantar pad naked, except sometimes for an ingrowth of hair internally behind the plantar pad ..... *Ursus*.
- e'. Pads smaller; sole of hind foot behind plantar pad overgrown with hair except for a small naked flat pad near the external border ..... *Thalarcos*.

*Melursus*, *Helarcos*, and *Thalarcos* are monotypical. *Tremarcos* contains two well-defined species, namely *thibetanus* and *ornatus* (type), which I cannot distinguish externally by any characters of generic value in my opinion. Nevertheless, the difference in the smoothness of the integument behind the first and fifth digital pads in *thibetanus* and its hairiness in *ornatus* is very curious. *Ursus* contains a doubtful number of species and subspecies, but I am not acquainted with any external features

\* This genus, or subgenus, is usually defined by the shortness and breadth of the skull, smallness of the ears, length of the tongue, etc.

justifying the admission of *Danis* (type *horribilis*) and *Euarctos* (type *americanus*), unless the more backward position of the first digit in the fore paw of *americanus* and the higher position of the carpal pad be given generic value—in my opinion, an exaggerated view of their importance\*.

As regards the genealogical position of the genera judged from their feet, analogy justifies the opinion that the naked-footed forms with free digital pads, like *Helarctos* and *Tremarctos*, are the more primitive†. From a stock probably resembling these in the particulars named, *Melursus* is specialised on one side by the fusion of the digital pads and *Ursus* on another side by the growth of hair over the carpal region. *Thalarctos* appears to me to be nothing but a specialised type of *Ursus*, adapted for swimming and movement on ice, its longer and more powerful canine teeth being developed for the seizing and slaying of seals.

\* Merriam admits *Euarctos* as a subgenus of *Ursus* on account of certain cranial and dental differences. *Danis*, however, appears to be undefinable (Proc. Biol. Soc. Wash. x. pp. 65, 83, 1896).

† In the bears themselves this view finds support in the scantiness and shortness of the hairs clothing the areas behind the digital and carpal pads in the newly-born cubs of *Thalarctos maritimus* and *Ursus arctos*.

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## EXHIBITIONS AND NOTICES.

June 9, 1914.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President,  
in the Chair.

The SECRETARY read the following report on the additions to the Society's Menagerie during the month of May 1914 :—

The number of registered additions to the Society's Menagerie during the month of May was 230. Of these 116 were acquired by presentation, 36 by purchase, 43 were received on deposit, 10 in exchange, and 25 were born in the Gardens.

The number of departures during the same period, by death and removals, was 220.

Amongst the additions special attention may be directed to :—

2 Bladder-nosed Seals (*Cystophora cristata*) ♂ ♀, from Greenland, purchased on May 18th.

1 Reindeer (*Rangifer tarandus*) ♂, born in the Menagerie on May 9th.

6 Long-tailed Bats (*Rhinopoma microphyllum*), from India, new to the Collection, received in exchange on May 12th.

4 Red-headed Bullfinches (*Pyrrhula erythrocephala*), from the Himalayas, new to the Collection, and 2 Cotton-Teal (*Nettion coromandelianus*), from India, presented by Alfred Ezra, F.Z.S., on May 15th.

2 Cuvier's Toucans (*Ramphastos cuvieri*), from the Upper Amazons, purchased on May 12th.

1 Maximilian's Parrot (*Pionus maximiliani*), from Brazil, and 2 Petz's Conures (*Conurus canicularis*), from Mexico, presented by the Marquess of Tavistock, F.Z.S., on May 28th.

2 Open-bills (*Anastomus oscitans*), from India, purchased on May 20th.

Mr. J. THORNTON CARTER, F.Z.S., exhibited microphotographs showing phases of mitosis in the cells of the enamel organ in *Dasyurus viverrinus* and *Trichosurus vulpecula*. The demonstration of mitosis in the enamel cells has not been recorded previously—in fact, little has been published dealing with the cytological changes which produce the differentiation of the various cells composing an enamel organ.

In a paper to be submitted to the Society during the next session, Mr. Carter deals at length with the cytology of the cells of the enamel organ in Mammals, Reptiles, Fishes, etc., in all of which abundant evidence of mitosis has been found.

Mr. R. I. Pocock, F.R.S., F.L.S., F.Z.S., Curator of Mammals, exhibited on behalf of Major C. P. BRADSHAW an interesting example of Sömmering's Gazelle (*G. sømmeringi*), shot on the Dinder River in Sennar, and mounted by Messrs. Edward Gerrard & Sons. The antelope was remarkable for the whiteness of its pelage, which showed scarcely a trace of the gazelline tint characteristic of the typical form. That the specimen was not an albino was shown by the persistence of the typical black markings on the face, the black horns and hoofs, and the black tuft on the tail.

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#### NOTICE.

*Euvallentinia* nom. n. for *Vallentinia* Stebbing.

Mr. Edward T. Browne having kindly called my attention to the circumstance that a medusoid genus was named *Vallentinia* by him in 1902, and further that a genus of Copepoda was so named by Norman and Scott in 1906 (Crustacea of Devon and Cornwall, p. 172), I now propose the new name *Euvallentinia* for the genus of Isopoda which I myself have recently called *Vallentinia* (P. Z. S. 1914, p. 351), leaving it to the joint authors to propose an alternative name for their genus of Copepoda, unless it should prove that the want has been already supplied, either intentionally or incidentally, by some other authority.

(Signed) T. R. R. STEBBING.

Ephraim Lodge,  
The Common,  
Tunbridge Wells.  
August, 1914.





ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

June 9th, 1914.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President,  
in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions to the Society's Menagerie during the month of May, 1914.

Mr. J. THORNTON CARTER, F.Z.S., exhibited microphotographs showing phases of mitosis in the cells of the Enamel Organ in *Dasyurus viverrinus* and *Trichosurus vulpecula*. The demonstration of mitosis in the enamel cells has not been recorded previously—in fact, little has been published dealing with the cytological changes which produce the differentiation of the various cells composing an enamel organ.

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\* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

Prof. J. STANLEY GARDINER, M.A., F.R.S., F.Z.S., gave an account of a Report on the Fauna of the Monte Bello Islands by Mr. P. D. Montague, B.A.

The islands are briefly described before considering the fauna; they are barren limestone with a limited vegetation and some mangroves. There are two indigenous mammals, *Lagorchestes conspicillatus* (Gould) and *Isoodon barrowensis* Thom. Of the twelve land-birds three new forms have been described elsewhere; the reptiles number eleven, one being new, and show a marked reduction in size as compared with continental specimens. Of insects there are recorded 22 Lepidoptera, 11 Coleoptera, 13 Hymenoptera, and some Orthoptera, etc. Myriapoda number 9 species; there is 1 scorpion. 9 fishes from lagoons are named.

The collections prove conclusively the entire dependence of these islands for their fauna on the neighbouring continent. Partial depopulations of the islands owing to drought are suggested, succeeded by repopulations by means of wind-borne forms from the south.

Three other papers, also dealing with collections made by Mr. Montague at the Monte Bello Islands, were received from Mr. G. C. ROBSON on Cephalopoda, from Miss M. J. RATHBUN on Stalk-eyed Crustaceans, and from Mr. TOM IREDALE on Mollusca.

Dr. W. A. CUNNINGTON, M.A., F.Z.S., read a paper on the parasitic Eucopepoda collected by the Third Tanganyika Expedition in 1904-1905. The collection consisted of a very small number of specimens, these forms being evidently much rarer than the Argulidae, which are also external parasitic Copepods infesting fish. The specimens were referred to the well-known fresh-water genus *Lerneocera*, and belong to two species both described as new. One of these, however, differs considerably from the more typical members of the genus, and may merit a separation from it in the light of further knowledge. A third species of *Lerneocera*, which was taken on a Nile fish and belongs to the collections of the British Museum, was also described in the paper.

Dr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society, read a paper containing the description of a new species of Avian Cestodes and a further discussion of the paruterine organ in *Otiditenia*.

Mr. R. I. Pocock, F.R.S., F.L.S., F.Z.S., Curator of Mammals, read a paper "On the Facial Vibrissæ of Mammalia," and pointed out that in all the principal orders of the class, with one or two exceptions, the following groups of vibrissæ are present in some genera:—mystaciale on the upper lip, submental on the chin and lower lip, superciliary over the eyes, gonial on the cheeks, and interramal on the throat behind the symphysis of the jaw.

Within the limits of the orders these tufts are present in the primitive genera, but more or fewer of them may be lost in the more specialised types. This fact, coupled with their prevalence in widely different types, points to the arrangement of the vibrissæ above indicated being exceedingly primitive. The different modifications of the vibrissæ met with in various orders were briefly pointed out.

A second paper by Mr. Pocock "On the Feet and other External Features of the Canidæ and Ursidæ," based like the last upon work done in the Society's Prosectorium, dealt with the rhinaria, the facial vibrissæ, and the pads and interdigital integument of the feet in many of the genera of Canidæ and all the admitted genera of Ursidæ. In connection with the Canidæ the most interesting results were the discovery of evidence, supplied by the feet, of kinship between *Cuon* and *Lycaon*, and between *Otocyon* and *Vulpes*. On the other hand, two of the South American fox-like dogs *Cerdocyon microtis* and *Bendalopex gracilis* differ widely from each other in the structure of the feet, and equally widely from *Vulpes* and *Otocyon*. The most aberrant of all the dogs in the matter of foot-structure is *Speothos* (*Icticyon*), which is unique in having the digital pads of the third and fourth toes of both front and hind feet united, and in having the pollex of the front foot set low down adjacent to the postero-internal angle of the main or plantar pad. These differences seem to justify the division of the Canidæ into the two sub-families *Speothoinæ* and *Caninæ*.

In the Ursidæ four well-marked genera are characterised by the structure of the feet, namely, *Thalarcos* for *maritimus*, *Ursus* for *arctos* and its allies *horribilis* and *americanus*, *Tremarctos* for *thibetanus*, *japonicus*, *ornatus*, and *malayanus*, and *Melursus* for *ursinus*. *Melursus* differs from the rest in having all the digital pads united almost to their distal ends. *Tremarctos* differs from *Ursus* in having the area behind the main or plantar pad of the fore foot quite naked, instead of thickly hairy as in *Ursus* and *Thalarcos*, and *Thalarcos* differs from *Ursus* in having the plantar pads wide and short and the area of the sole behind the plantar pad of the posterior foot covered with hair except for a small lozenge-shaped pad towards its outer border. From *Tremarctos*, *malayanus* may be eliminated as *Helarctos* by the structure of the rhinarium. All the generic names adopted in the paper had been previously proposed, mainly upon cranial and dental characters; but the evidence from this source is so unsatisfactory that there has been no agreement amongst zoologists in their recognition.

Dr. G. A. BOULENGER, F.R.S., F.Z.S., contributed a paper entitled "A Second Collection of Batrachians and Reptiles made by Dr. H. G. F. Spurrell, F.Z.S., in the Choco, Colombia."

A paper on *Procolophon trigoniceps*, a Cotylosaurian Reptile from South Africa, was received from Mr. D. M. S. WATSON, M.Sc., F.Z.S.

Mr. A. W. WATERS presented a paper on the "Marine Fauna of British East Africa and Zanzibar, from Collections made by Cyril Crossland, M.A., B.Sc., F.Z.S., in the Years 1901-1902: Bryozoa—Cyclostomata, Ctenostomata, and Endoprocta."

Out of the twenty-four species from these three groups, four are new; and, as the species mentioned are all from 10 fathoms or under, it will not occasion surprise that the number of Cyclostomata is but small.

Sections of the ovicells of *Entalophora* and *Idmonea* are figured, and stress is again laid on the importance of the ovicells in the classification of the Cyclostomata, and it is also thought that the primary and early zoëcia may give valuable help. The ovicells and other points indicate that some "*Entalophora*" have Diastoporidan characters necessitating separation. General particulars are given as to the ovicells of the Cyclostomata.

It is shown that the rosette-plate of *Zoobotryon pellucidum*, described by Reichert as having a central pore with 8-9 pores round it, has only one pore, but that surrounding it there are a number of cells, so that there is a rosette of cells instead of a rosette of pores. Also the groups of cells in the neighbourhood of the rosette-plate have a fairly definite form, changing with the species in some cases, thus furnishing specific characters.

In a note, further proof is brought forward showing that the genus *Lagenipora* Hincks should be retained for a group recently included in *Cellepora*, and *Siniopelta* Levinsen is a synonym. Also the *Celleporella* Norman is *Lagenipora*.

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This Meeting closes the Session 1913-1914. The next Meeting of the Society for Scientific Business will be held on Tuesday, October 27th, 1914, at half-past FIVE o'clock P.M.

The following papers have been received:—

W. L. DISTANT.

Report on the Rhynchota collected by the Wollaston Expedition in Dutch New Guinea.

T. H. WITHERS, F.G.S.

A remarkable new Cirripede from the Chalk of Surrey and Hertfordshire.

F. A. POTTS, M.A.

Polychæta from the N.E. Pacific: The Chætopteridæ. With an Account of the Phenomenon of Asexual Reproduction in *Phyllochætopterus* and the Description of Two new Species of Chætopteridæ from the Atlantic.

F. E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S.

Contributions to the Anatomy and Systematic Arrangement of the Cestoidea.—XV. On a new Genus and Species of the Family Acoleidæ.

D. M. S. WATSON, M.Sc., F.Z.S.

- (1) A new Fossil Reptile from South Africa.
- (2) Notes on some Carnivorous Therapsids.
- (3) *Eunotosaurus africanus* Seeley, and the Ancestry of the Chelonia.

E. HERON-ALLEN, F.L.S., F.G.S., F.R.M.S., and ARTHUR EARLAND, F.R.M.S.

The Foraminifera of the Kerimba Archipelago, Portuguese East Africa.

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Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,  
REGENT'S PARK, LONDON, N.W.

June 16th, 1914.







ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

October 27th, 1914.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President,  
in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions to the Society's Menagerie during the months of June, July, August, and September, 1914.

Mr. R. H. BURNE, M.A., V.P.Z.S., exhibited a number of preparations showing some adaptations for the nourishment of the embryos of Elasmobranchs.

Mr. R. E. SAVAGE exhibited two abnormal Herrings, taken by trawl in the North Sea. The first specimen had neither pelvic fins nor girdle (pelvic bones). The usual position of base of fins was indicated externally by the presence of the characteristic elongated scales. The usual musculature was present internally. The second specimen lacked the left pelvic fin and pelvic bone; the musculature was complete.

Messrs. E. HERON-ALLEN, F.L.S., F.Z.S., and ARTHUR EARLAND, F.R.M.S., read a paper on the Foraminifera of the Kerimba Archipelago, obtained by Dr. J. J. Simpson in the years 1907-8. The area is a new one so far as the Foraminifera are concerned, the only records in any way approximating to it being the species described by d'Orbigny in 1826, by Brady in 1876 and 1884, by Möbius in 1880, and by Egger in 1893, from material which was collected from adjacent areas to the East of Madagascar, and off Mauritius and the Seychelles.

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\* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

The material consisted of fine siftings from dredgings, and having but few molluscan fragments and stones the larger adherent forms are poorly represented, but 470 species and varieties have been identified, including two new genera, and 28 new species and varieties. The general facies is strikingly similar to that characteristic of Australian, Torres Straits, and Malay gatherings. The problem of distribution thus raised is obscure, the intervening ocean being abyssal, while the species now recorded are all shallow-water types. Many of the specialized forms common to these widely separated areas do not apparently occur in similar dredgings from intervening coasts such as the Red and Arabian Seas. No doubt the Equatorial Current, which traverses the Indian Ocean from E. to W. and impinges on the African coast in our area, is primarily responsible for this phenomenon.

Among the striking forms described and exhibited were *Ammodiscus charoides* (Jones & Parker), now recorded for the first time as a tropical species; *Carterina spiculotesta* (Carter), exhibiting a hitherto unrecorded arrangement of the spicules; *Pavonina flabelliformis* d'Orbigny, originally discovered by d'Orbigny in sand from Madagascar in 1826 and lost sight of for fifty years; *Chrysalidina dimorpha* Brady, a rare and beautiful Textularian; *Discorbina dimidiata* Parker & Jones, and *Discorbina polystomelloides* Parker & Jones; *Cymbalopora bulloides* d'Orbigny, the dual nature of the terminal chamber, being divided into a "balloon" and a contained "float" chamber, was described; also the species *Cymbalopora millettii* Heron-Allen & Earland, first recorded from the Malay Archipelago by Mr. F. W. Millett. A new record was established for *Haddonina torresiensis* Chapman, hitherto only found in the Torres Straits and the Tropical Pacific.

This paper will be published in the 'Transactions.'

Mr. T. H. WITHERS, F.G.S., described a new Cirripede based on a number of disconnected valves from the Chalk of Surrey and a complete specimen from the Chalk of Hertfordshire. Except for three valves referred to a new species of *Scalpellum* (*sensu lato*), the whole of the material belongs to a remarkable new asymmetrical Cirripede which differs from *Verruca* in the more primitive structure of the valves, in the presence of two lower lateral valves on the rostro-carinal side, and in the absence of interlocking ribs. This species undoubtedly represents the ancestral type from which has arisen the recent group of asymmetrical sessile Cirripedes forming the family Verrucidae, and in its structure clearly shows its origin from the symmetrical pedunculate Cirripedes of the family Pollicipedidae. It presents further evidence that the sessile condition was arrived at independently on several different lines of descent during the evolution of the Cirripedia.

Mr. W. L. DISTANT communicated his report on the *Rhynchota* collected by the Wollaston Expedition in Dutch New Guinea.

This paper will be published in the 'Transactions.'

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 10th, 1914, at half-past FIVE o'clock P.M., when the following communications will be made:—

LEWIS BALFOUR.

Exhibition of Photographs illustrating the Life-history of the Garnet.

R. I. POCKOCK, F.R.S., F.L.S., F.Z.S.

Lantern exhibition showing the Differences between the Pine and Beech Martens.

F. E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S.

Contributions to the Anatomy and Systematic Arrangement of the Cestoidea.—XV. On a new Genus and Species of the Family Acoleidæ.

H. R. HOGG, M.A., F.Z.S.

Report on the Spiders collected by the British Ornithologists' Union Expedition and the Wollaston Expedition to Dutch New Guinea.

The following papers have been received:—

F. A. POTTS, M.A.

Polychæta from the N.E. Pacific: The Chætopteridæ. With an Account of the Phenomenon of Asexual Reproduction in *Phyllochætopterus* and the Description of Two new Species of Chætopteridæ from the Atlantic.

D. M. S. WATSON, M.Sc., F.Z.S.

- (1) A new Fossil Reptile from South Africa.
- (2) Notes on some Carnivorous Therapsids.
- (3) *Eumotosaurus africanus* Seeley, and the Ancestry of the Chelonia.

KATHLEEN HADDEN.

On the Methods of Feeding and the Mouth-parts of the Larva of the Glow-worm (*Lampyrus noctiluca*).

G. STEWARDSON BRADY, M.D., LL.D., F.R.S., C.M.Z.S.

On Two new Subgenera of Freshwater Entomostraca.

WILLIAM NICOLL, M.A., D.Sc., M.D., F.Z.S.

A new Liver-fluke (*Platynosomum acuminatum*) from the Kestrel.

Lt.-Col. J. M. FAWCETT.

Notes on a small Collection of Heterocera made by Mr. W. Feather in British East Africa, 1911-12.

J. F. GEMMILL, M.A., D.Sc., F.Z.S.

Abnormal Gills in the Starfish, *Porania pulvillus* O. F. M.

F. F. LAIDLAW, M.A., F.Z.S.

Contributions to a Study of the Dragonfly Fauna of Borneo.  
—Part III. A Collection made on Mount Kina Balu by Mr. Moulton in September and October 1913.

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Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,

REGENT'S PARK, LONDON, N.W.

*November 3rd, 1914.*

ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

November 10th, 1914.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President,  
in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions to the Society's Menagerie during the month of October.

The SECRETARY exhibited a photograph showing Oysters growing upon mangroves at Lobito Bay, Portuguese West Africa.

Mr. L. H. JAMES, F.Z.S., communicated some notes upon the birth of a Porpoise at the Brighton Aquarium.

Mr. R. I. Pocock, F.R.S., F.L.S., Curator of Mammals, gave an exhibition, illustrated by lantern-slides, showing some unrecorded structural differences between the Pine-Marten (*Martes martes*) and the Beech-Marten (*Martes foina*), and pointed out that the two species, apart from the known differences in the skull and teeth, may be distinguished by the size of the ears, which are broader and longer in *M. martes* than in *M. foina*, and by the dimensions of the pads on the feet, which are considerably larger and less overgrown with hair in *M. foina* than in *M. martes*.

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Mr. R. H. BURNES, M.A., V.P.Z.S., exhibited some paraffin Simulacra of Molluscan and other shells made accidentally by Dr. C. V. ARIENS KAPPERS while embedding objects for the microtome. During this process, paraffin in a molten state accidentally escaped from the mould and set in the shell-forms shown, probably owing to distorted crystallization.

Dr. F. E. BEDDARD, M.A., F.R.S., Prosector to the Society, read a paper on the Anatomy and Systematic Arrangement of the Cestoidea, in which he described a new genus and species of the Family Acoelidae, based upon a large number of examples obtained from the Canadian Tree-Porcupine (*Erethizon dorsatum*).

Mr. H. R. HOGG, M.A., F.Z.S., read his report on the Spiders collected by the Wollaston and British Ornithological Union Expeditions in Dutch New Guinea. This collection confirms a good deal of the work of previous authors, and at the same time brings to light much that is new. Leaving out the Attidae, there are representatives of nine families, comprising twenty-six genera (of which one is new) and forty-five species or subspecies of which some nineteen are new. Included among the latter are the following:—

*CONOTHELE SPINOSA*, sp. n.

Differs from *C. malayana* Dol. in having the front lateral eyes twice as long as the rear laterals, the rear median smaller still, and the front median  $1\frac{1}{2}$  times as broad as the rear, instead of all the eyes equal. From *C. arboricola* Poc. in having the first pair of legs longest instead of the fourth, and four teeth only on the outer margin of the falc-sheath instead of six. From *C. doleschalli* Thor. similarly in the legs, and the latter has the rear median and side eyes close together.

*SELENOCOSMIA LANCEOLATA*, sp. n.<sup>1</sup>

Differs from *S. similis* Kulc. and *A. honesta* Hirst, possibly the same, in having the patella cum tibia and metatarsus cum tarsus about the same length as, or shorter than, the femur and trochanter in the first three pairs of legs instead of much longer. The abdomen is paler and the lip and maxillæ the same colour all over instead of being particoloured.

Length 34 mm.

*PSECHRUS CASTANEUS*, sp. n.

Differs from *P. argentatus* Thor., *P. libeltii* Kulc., and *P. annulatus* Kulc. in having the legs longer in proportion, the front pair being more than ten times as long as the cephalothorax instead of about eight, in having the front median eyes as large as the side instead of smaller, and the rear median eyes more than their diameter apart instead of less. It is also only two-thirds the size of the first-named and larger than the last.

Length 17 mm.

*FECENIA CINEREA*, sp. n.

Differs from *F. sumatrana* Kulc. in its first pair of legs eight times the length of the cephalothorax instead of about six, in the median eye-square broader than long, and the rear row distinctly procurved instead of nearly straight. The epigyne also differs considerably, though rather near to Mr. Rainbow's drawing of his *F. oblonga* from the Solomon Islands.

Length 10 mm.

*ARANEUS FLORIATUS*, sp. n.

Differs from *A. pfeifferi* Thor. and *A. ferruginea* Thor. ('Ragni di Selebes,' pp. 35, 38), besides a more elaborate back pattern, in having the median eye-area broader than long instead of longer than broad, and the median eyes distant from the side eyes by twice instead of three times their distance between one another, also scape of epigyne four times as long as its greatest breadth instead of twice.

2 females, 1 male. Length 17 mm.

*ARANEUS GRANTI*, sp. n.

Differs from *A. vatus* Thor. (*loc. cit. supra*, p. 41), which it rather closely resembles, in having the front median eyes their diameter apart instead of much more. The sternum is bright cream-colour instead of dark yellow-brown. The scape of the epigyne issues from the upper part of the corpus instead of the lower margin, is  $2\frac{1}{2}$  times as long as the width of the corpus instead of twice, and in the middle widens to twice its narrowest part above instead of being straight, four times instead of twice as long as broad.

1 female. Length  $12\frac{1}{2}$  mm.

*LEUCAUGE CAUDATA*, sp. n.

Differs from *Araneus caudifer* Kulc., which it rather resembles, in its smaller size, the legs only half as long, its colouring silvery instead of reddish brown, the rear median eyes half their diameter apart instead of more than their diameter, so that the area of the median eyes is narrowest instead of widest posteriorly. The epigyne has a bulbous base, wanting in the other, but a shorter scape.

Length 8 mm.

*REGILLUS DIVERGENS*, sp. n.

Differs from *R. asper* Camb. in its larger size, the eyes of the rear row slightly recurved instead of straight, equidistant instead of median nearer together than they are from the side, thus forming with the front median eyes a square instead of trapezium narrowest posteriorly.

Length 12 mm.

*OLIOS PRINCEPS*, sp. n.

Cephalothorax chestnut-red with pale red-brown bristles and hair. Abdomen pale yellow-brown with faint median and branching stripes of a darker colour, short longitudinal flecks of the same on the sides merging into longer underneath to form a shield-shaped pattern, above and just below the genital fold dark brown, on the latter a streak of white. Mandibles, lip, and maxillæ black-brown; sternum bright red, legs and palpi bright red-brown with brown hairs, that on the coxæ black-brown. Vulva a broad chitinous horseshoe-frame, widely open at the base, the hollowed inner area indistinctly divided by a median longitudinal fovea.

1 female. Length 23 mm.

*OLIOS ACTEON*, sp. n.

Differs from *Olios salacius* L. K. in having the median eyes of the rear row (which is slightly procurved) distinctly farther apart than they are from the front median. The sternum bright yellow with eight black hair-spots ranged round just inside the margin instead of brownish yellow with white hair-stripes, pattern on underside of abdomen like *Olios* (*Het.*) *diana* L. K. Five large teeth and one smaller on the inner falk-margin and two on the outer, instead of three and one respectively. The palp is furnished with a spiral of ten turns round the usual drum. It is also rather smaller.

1 male. Length  $13\frac{1}{2}$  mm.

*PALYSTES DASYURINUS*, sp. n.

Differs from *P. ignicomus* L. K. in having ten white hair-spots on black shield on underside of the abdomen, front median eyes their diameter apart and half that distance from the laterals, three large teeth and one rather smaller on inner margin of falk-sheath, one large between two smaller on outer—a single, long, curved bristle on upper inner margin of falk.

1 female. Length 25 mm.

*HETEROPODA VENATORIA* Linn., var. *PLURIDENTATA*, nov.

Differs from usual form in having five large teeth and one smaller on inner margin of falk-sheath, one medium-sized and two smaller on outer margin.

2 females.

## EXOPALYSTES, gen. nov.

Intermediate between the groups Deleneae and Heteropodea, but near *Palystes* L. K., differing therefrom in having the front median eyes as large as the side eyes, the eyes of the front row larger than those of the rear row, the eyes all sessile and the clypeus about twice as broad as a front median eye. The cephalothorax, highest in the posterior one-third, sloping to the front, and a thick fringe of long bristles on the upper inner margin of falk instead of one single bristle.

## EXOPALYSTES PULCHELLA, sp. n.

Pale yellow with white hair all over, except underside of femora i. and ii. which is dark grey. Here and under the tibiae of the same pairs a thick mat of long recumbent cylindrical bristles on the anterior two-thirds of the joints.

1 female. Length 18 mm.

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 24th, 1914, at half-past FIVE o'clock P.M., when the following communications will be made:—

EXHIBITIONS AND NOTICES.

E. HERON-ALLEN, F.L.S., F.Z.S., and ARTHUR EARLAND, F.R.M.S.

Exhibition of Tests of Arenaceous Foraminifera to introduce a Discussion on the Interpretation of these Structures.

D. M. S. WATSON, M.Sc., F.Z.S.

- (1) A new Fossil Reptile from South Africa.
- (2) Notes on some Carnivorous Therapsids.
- (3) *Eunotosaurus africanus* Seeley, and the Ancestry of the Chelonia.

F. A. POTTS, M.A.

Polychæta from the N.E. Pacific: The Chætopteridæ. With an Account of the Phenomenon of Asexual Reproduction in *Phyllochætopterus* and the Description of Two new Species of Chætopteridæ from the Atlantic.

The following papers have been received :—

KATHLEEN HADDEN.

On the Methods of Feeding and the Mouth-parts of the Larva of the Glow-worm (*Lampyrus noctiluca*).

G. STEWARDSON BRADY, M.D., LL.D., F.R.S., C.M.Z.S.

On Two new Subgenera of Freshwater Entomostraca.

WILLIAM NICOLL, M.A., D.Sc., M.D., F.Z.S.

A new Liver-Fluke from the Kestrel.

Lt.-Col. J. M. FAWCETT.

Notes on a small Collection of Heterocera made by Mr. W. Feather in British East Africa, 1911-12.

J. F. GEMMILL, M.A., D.Sc., F.Z.S.

- (1) Abnormal Gills in the Starfish, *Porania pulvillus* O. F. M.
- (2) On the Ciliation of Asterids, and on the Question of Ciliary Nutrition in Certain Species.

F. F. LAIDLAW, M.A., F.Z.S.

Contributions to a Study of the Dragonfly Fauna of Borneo.  
—Part III. A Collection made on Mount Kina Balu by Mr. Moulton in September and October 1913.

E. G. BOULENGER, F.Z.S.

On a Colubrid Snake (*Xenodon*) with a vertically movable Maxillary Bone.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,  
*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,  
REGENT'S PARK, LONDON, N.W.  
November 17th, 1914.







ABSTRACT OF THE PROCEEDINGS  
OF THE  
ZOOLOGICAL SOCIETY OF LONDON.\*

November 24th, 1914.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President, in the Chair.

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The Minutes of the last Scientific Meeting were confirmed.

Dr. R. BROOM, C.M.Z.S., exhibited the skull of a new type of Thecodont Reptile from the Upper Permian Beds of South Africa, and a number of skulls of *Trichosurus vulpecula*, *Phascolarctus cinereus*, *Chrysochloris hottentota*, and *C. asiatica*, illustrating dental variations.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited an egg of the New Guinea Rifle-bird (*Ptilorhis intercedens*), which had been laid in the Society's Gardens in July last, the first instance of any species of Paradise-Bird laying in the Gardens.

Mr. E. T. NEWTON, F.R.S., F.Z.S., exhibited a series of bones of animals showing indications of natural repair, and a number of teeth of a female Sperm-Whale (*Physeter macrocephalus*).

Dr. C. W. ANDREWS, F.R.S., F.Z.S., gave an account of three papers by Mr. D. M. S. WATSON.

The first paper contained the description of a new reptile from the Permian of the Cape Province, S. Africa, which Mr. Watson regards as derived from a Cotylosaurian ancestor and as perhaps related to *Aræoscelis* and the modern lizards. A new genus is

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founded for the reception of the so-called "*Proterosaurus huxleyi*."

In the second paper the origin of the Chelonia is discussed, and a number of reasons given for supposing that they may be descended from some such form as *Eunotosaurus africanus* Seeley.

In the third paper Mr. Watson describes the skulls of *Bauria*, *Microgomphodon*, and *Sesamodon*, and discusses the relation of the group with the Cynognathids. He also describes a new skull of *Lycosuchus*, in which both the prevomers and vomer are present.

Mr. F. A. POTTS, M.A., communicated a paper entitled "Polychæta from the N.E. Pacific: The Chaetopteridæ. With an Account of the Phenomenon of Asexual Reproduction in *Phyllochaetopterus* and the Description of Two new Species of Chaetopteridæ from the Atlantic."

The new species of *Phyllochaetopterus* was found in branched tubes, each usually containing several individuals. The origin of these colonies each from a single individual is suggested by the frequent occurrence of worms in various stages of regeneration. An examination of these shows that autotomy first occurs in the middle region of the animal's body, and a complete animal is regenerated from each of the two parts. This phenomenon appears to be characteristic also of another new species of this genus from Plymouth, which lives in small colonies in branched tubes.

Several points in the morphology of the Chaetopteridæ are also discussed.

MESSRS. E. HERON-ALLEN, F.L.S., F.Z.S., and ARTHUR EARLAND, F.R.M.S., exhibited a series of microscopic preparations and photographic views of the tests of Arenaceous Foraminifera, and urged their view that these afforded evidence of purpose and intelligence on the part of the Foraminifera.

An interesting discussion followed, in which, amongst others, Sir H. H. Howorth, F.R.S., Sir E. Ray Lankester, F.R.S., and the Secretary took part.

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The next Meeting of the Society for Scientific Business will be held on Tuesday, February 9th, 1915, at half-past FIVE o'clock P.M. The Agenda for this Meeting will be circulated early in January.

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The following papers have been received :—

KATHLEEN HADDON.

On the Methods of Feeding and the Mouth-parts of the Larva of the Glow-worm (*Lampyrus noctiluca*).

G. STEWARDSON BRADY, M.D., LL.D., F.R.S., C.M.Z.S.

On Two new Subgenera of Freshwater Entomostriaca.

WILLIAM NICOLL, M.A., D.Sc., M.D., F.Z.S.

A new Liver-Fluke from the Kestrel.

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- (1) Abnormal Gills in the Starfish, *Porania pulvillus* O. F. M.
- (2) On the Ciliation of Asterids, and on the Question of Ciliary Nutrition in Certain Species.

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Contributions to a Study of the Dragonfly Fauna of Borneo.  
—Part III. A Collection made on Mount Kina Balu by Mr. Moulton in September and October 1913.

E. G. BOULENGER, F.Z.S.

On a Colubrid Snake (*Xenodon*) with a vertically movable Maxillary Bone.

ROWLAND E. TURNER.

Descriptions of New Fossorial Wasps from Australia.

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Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

*Secretary.*

ZOOLOGICAL SOCIETY OF LONDON,

REGENT'S PARK, LONDON, N.W.

*December 1st, 1914.*

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## NOTICE.

The 'Proceedings' for the year are issued in *four* parts, paged consecutively, so that the complete reference is now P. Z. S. 1914, p. . . . The Distribution is as follows:—

Part I. issued in March.

„ II. „ June.

„ III. „ September.

„ IV. „ December.

'Proceedings,' 1914, Part II. (pp. 227-490), were published on  
June 16th, 1914.

The Abstract of the 'Proceedings,' No. 135, is  
contained in this Part.

PROCEEDINGS  
OF THE  
GENERAL MEETINGS FOR SCIENTIFIC BUSINESS  
OF THE  
ZOOLOGICAL SOCIETY  
OF LONDON.  
1914.

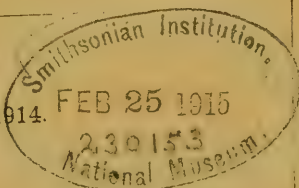
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PART IV:

CONTAINING PAGES 945 TO 1077, WITH 9 PLATES,  
36 TEXT-FIGURES, TITLEPAGE, INDEX, ETC.

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DECEMBER 1914.



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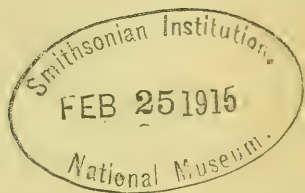
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THIS Society was founded in 1826 by Sir STAMFORD RAFFLES, Mr. J. SABINE, Mr. N. A. VIGORS, and other eminent Naturalists, for the advancement of Zoology and Animal Physiology, and for the introduction of new and curious subjects of the Animal Kingdom, and was incorporated by Royal Charter in 1829.

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The Society consists of Fellows, and Honorary, Foreign, and Corresponding Members, elected according to the By-Laws. It carries out the objects of its foundation by means of the collection of living animals, by its Library, and by its Scientific Publications.

The Office of the Society, Regent's Park, N.W., where all communications should be sent, addressed to "The Secretary," is open from Ten till Five, except on Saturdays, when it closes at ONE P.M.

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The Library is closed from Good Friday to Easter Monday, and upon all other Bank Holidays. It is also closed annually for cleaning purposes during the whole month of September.

The Meetings of the Society for General Business are held in the Meeting Room at the Society's Office on the third Wednesday in every month of the year, except in September and October, at half-past Four o'clock P.M.

The Meetings for Scientific Business are held in the Meeting Room at the Society's Office fortnightly on Tuesdays, except in July, August, September, and December and January, at half-past Five o'clock P.M.

The Anniversary Meeting is held on the 29th. of April, or the nearest convenient day, at Four P.M.

The Society's Gardens are open daily from Nine o'clock until Sunset. Mr. R. I. Pocock, F.R.S., F.L.S., is the resident Superintendent and Curator of Mammals, Mr. D. Seth-Smith is Curator of Birds and Inspector of Works, Mr. E. G. Boulenger is Curator of Reptiles, and Prof. H. M. Lefroy is Curator of Insects. The Prosectorium for Anatomical and Pathological work is under the charge of Mr. Frank E. Beddard, M.A., D.Sc., F.R.S., Prosector, assisted by Mr. H. G. Plimmer, F.R.S., M.R.C.S., Pathologist to the Society.

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Any FELLOW, having paid all fees due to the Society, is at liberty to withdraw his or her name upon giving notice in *writing* to the Secretary.

Ladies or Gentlemen wishing to become Fellows of the Society are requested to communicate with "The Secretary."

P. CHALMERS MITCHELL,

*Secretary.*

Regent's Park, London. N.W.  
December, 1914.

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OF THE  
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FOR  
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1915.

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# ZOOLOGICAL SOCIETY OF LONDON.

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## LIST OF PUBLICATIONS.

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THE scientific publications of the Zoological Society of London are of two kinds—"Proceedings," published in an octavo form, and "Transactions," in quarto.

According to the present arrangements, the "Proceedings" contain not only notices of all business transacted at the scientific meetings, but also all the papers read at such meetings and recommended to be published in the "Proceedings" by the Committee of Publication. A large number of coloured plates and engravings are issued in the volumes of the "Proceedings," to illustrate the new or otherwise remarkable species of animals described therein. Amongst such illustrations, figures of the new or rare species acquired in a living state for the Society's Gardens are often given.

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An "Abstract of the Proceedings" is published by the Society on the Tuesday following the date of the Scientific Meeting to which it refers. It is issued along with the "Proceedings," free of extra charge, to all Fellows who subscribe to the Publications, but it may be obtained on the day of publication at the price of Sixpence, or, if desired, sent post free for the sum of Six Shillings per annum, payable in advance.

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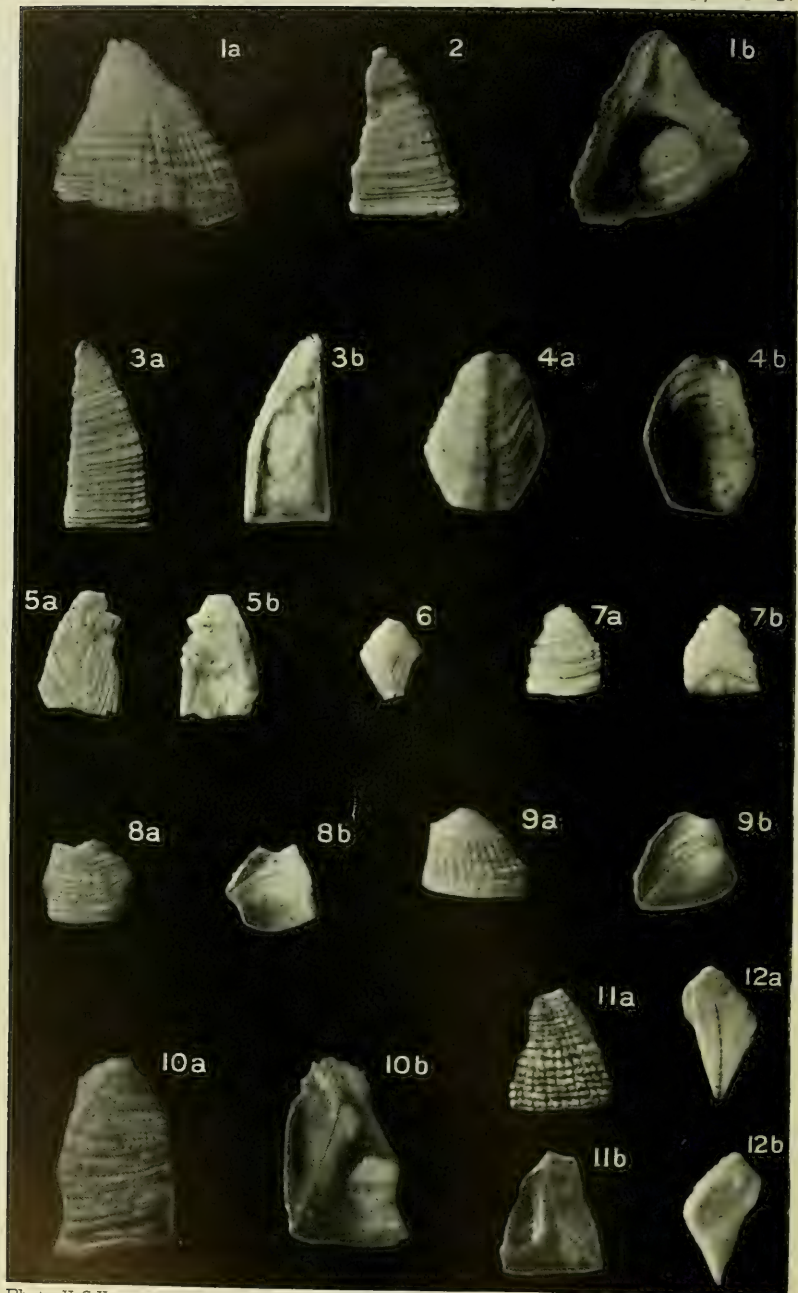
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1-9. PROVERRUCA VINCULUM.

10-12. SCALPELLUM VIMINEUM.

## PAPERS.

50. A remarkable new Cirripede from the Chalk of Surrey and Hertfordshire. By THOMAS H. WITHERS, F.G.S.\*

[Received May 27, 1914: Read October 27, 1914.]

(Plate I.† and Text-figure 1.)

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Among some Cirripede remains recently collected from the Chalk of Surrey are a number of isolated valves, which, together with a remarkably complete specimen of the same species from the Chalk of Watford, Hertfordshire, throw much light on the evolution of the sessile Cirripedes of the family Verrucidae. They constitute, in fact, the "missing link" between the pedunculate Cirripedes of the family Pollicipedidae and the sessile asymmetrical Cirripedes of the family Verrucidae.

The valves from Surrey were obtained by me from a mass of unusually soft Chalk found by Mr. C. P. Chatwin in the Slines Oak Pit, Worms Heath, near Woldingham, and to judge from the single example of *Micraster præcursor* collected from the same horizon, the chalk appears to be in the upper part of the zone of *Micraster cor-testudinarius*. This is the zone to which it has been assigned by Mr. G. W. Young‡.

Much difficulty was experienced in studying these valves, for although they were all somewhat similar in external ornament, the scuta and terga differed so much in structure that it was apparent that more than one species was represented. What was evident, however, was that certain of the scuta and terga, apparently of the same species, were extremely convex transversely and formed a semicircle when placed in position. This fact suggested to me the possibility of their belonging to a new form of sessile Cirripede, since if the capitulum were completed it would approach more closely to radial symmetry than is the case in an ordinary

\* Communicated by Dr. W. T. CALMAN, F.Z.S.

† For explanation of the Plate see p. 953.

‡ 1905. "The Chalk Area of North-east Surrey," Proc. Geol. Assoc. London, vol. xix. p. 208 (pit 127a).

pedunculate Cirripede. It was at this stage of my observations that I went to examine some Cirripedes at the Museum of Practical Geology, and among them noticed a beautifully complete example of the species to which most of the isolated valves belong. This fine specimen was collected by Mr. J. Rhodes from the "Upper Chalk of Watford Tunnel,"\* and was apparently obtained from a hollow flint at about the same horizon as the isolated valves from Surrey.

Through the kindness of the Director of the Geological Survey and Dr. F. L. Kitchin, I was enabled to borrow this specimen for description.

Although this new Cirripede occupies a position intermediate between the Pollicipedidæ and the Verrucidæ, I do not think it advisable to found a new family for its reception. It will, I think, be sufficiently distinguished if it is placed in a new genus, and the diagnosis of the family Verrucidæ extended to include it, since it is undoubtedly a primitive Verrucid.

The remaining valves, which obviously do not belong to this Verrucid, are described as a new species of *Scalpellum* (*sensu lato*).

#### Family VERRUCIDÆ emend.

Sessile, asymmetrical, box-like\* barnacles, in which a scutum, tergum, rostrum, and carina, with or without a rostral- and a carinal-latus in addition, are immovably united to form the "wall"; the remaining scutum and tergum are movable, and form the lid-like top.

#### PROVERRUCA, gen. nov.

Verrucids in which a rostral- and a carinal-latus are present on the rostro-carinal side, and in which none of the valves has developed interlocking ribs.

PROVERRUCA VINCULUM†, sp. n. (Pl. I. figs. 1-9; Text-fig. 1, C-F.)

*Material*.—(1) A single complete individual in which the movable scutum is somewhat displaced, and the upper portion of the rostral-latus broken away. (2) A number of isolated valves comprising:—1 fixed scutum (left), 6 fixed terga (5 right and 1 left), 4 movable scuta (1 right and 3 left), 2 movable terga (left), 1 carinal-latus (right), and 2 rostral lateral valves (left). There are no isolated examples of the rostrum and carina. Seven individuals are represented by these remains.

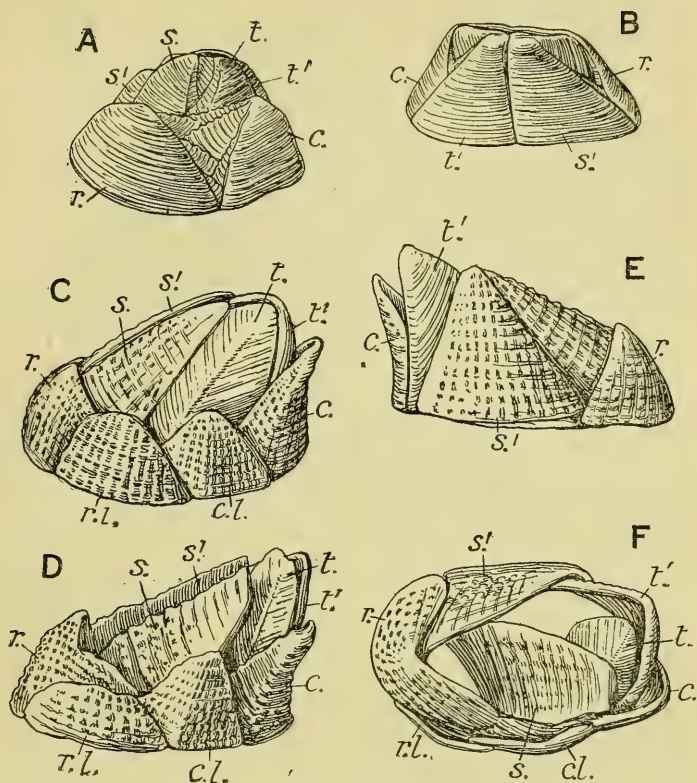
*Holotype*.—The complete specimen (text-fig. 1, C-F), Museum of Practical Geology, register number 3204.

*Horizon and locality*.—Lower Senonian, Upper part of *M. cor-tetudinarium*-zone: Slines Oak Pit, Worms Heath, Woldingham, Surrey. ? Same horizon: Watford Tunnel, Hertfordshire.

\* 1889. Mem. Geol. Surv., Geology of London, vol. i. p. 77; 1904. Mem. Geol. Surv., Cretaceous Rocks, vol. iii. p. 232.

† *vinculum*, a bond.

Text-figure 1.



A. *Verruca prisca* J. Bosquet. Upper Senonian to Danian: Europe. Rostrocarinal view showing the movable opercular valves, which are on the right side.

B. Opposite view of same showing the fixed scutum and tergum.

C. *Proverruca vinculum*, gen. et sp. n. Lower Senonian: England. Restoration of specimen below (fig. D), and from almost the same position.

D. *Proverruca vinculum*, gen. et sp. n. Lower Senonian, ? zone of *Micraster cor-testudinarium*: Watford Tunnel, Hertfordshire. Coll. Mus. Pract. Geol., No. 3204. A complete shell in which the movable scutum and tergum are on the right side and slightly displaced. The rostral- and the carinal-latus are seen, but the rostral-latus has its upper part broken away showing the lateral portion of the rostrum below.

E. Opposite view of same showing the fixed scutum and tergum.

F. Same specimen viewed from above to show the broadly oval outline of the shell, and the semicircular outline formed by the fixed scutum and tergum.

c., carina; c.l., carinal-latus; r., rostrum; r.l., rostral-latus; s., movable scutum; s', fixed scutum; t., movable tergum; t', fixed tergum.

All figures  $\times 15$  diam.

*Measurements.*—The complete shell is very minute, its dimensions being :—

|   |         |
|---|---------|
| Length (from base of rostrum to apex of carina) | 2·7 mm. |
| „ (from apex „ „ „)                             | 2·1 mm. |
| Greatest breadth .....                          | 1·7 mm. |
| „ height (from apex of tergum to base)...       | 1·6 mm. |

The isolated valves are somewhat larger, and indicate that the complete specimen is a young individual. Their dimensions are :—

Movable scutum : length (from apex to middle of basal margin) 2·8 mm. ; breadth (greatest) 1·2 mm.

Fixed scutum : length (from apex to middle of basal margin) 2·7 mm., when complete, ca. 2·9 mm. ; length (from apex to rostral angle) 3·1 mm. ; breadth (greatest) 2·7 mm.

Fixed tergum : length 2·4 mm. ; breadth 1·7 mm.

#### *Description of Specimens.*

Although the complete specimen is of great importance as showing the relative position of the valves, little can be seen of their inner structure. Moreover, the valves are covered exteriorly by a film of chalk, or may be a secondary deposit of silica, which serves both to obscure and unduly to emphasize the bead-like ornament. This is no doubt due to the shell having been preserved in a hollow flint, for preservation in flints is apt, especially in highly ornamented forms, to make the ornament more pronounced. Owing to its importance it is too dangerous to attempt to clean this minute and delicate fossil, and it will have to be studied in its present condition.

The isolated valves vary considerably both in ornament and structure, but while there is no doubt as to the identity of the fixed and movable scuta and terga, it is not at all certain that the rostral- and the carinal-latus belong to this species. In the complete specimen the rostral-latus is much broken, and the outer structure of this and the carinal-latus somewhat obscured. Without being able to disarticulate these valves it is impossible to compare them with the supposed isolated examples, of which even the two rostral latera differ from each other. It is probable that the variation in ornament is due to varying states of preservation.

The shell is broadly oval in outline, much elevated, the walls perpendicular on each side, and the movable scutum and tergum, when in position, would be inclined at an angle of about 30° with the base ; rostrum and carina at either end, the rostrum wider than the carina and slightly more developed on the right side, the space between the rostrum and carina occupied on one side by the fixed scutum and tergum, and on the other by the carinal-latus, the rostral-latus for its whole length overlapping the lateral portion of the rostrum.

Valves highly ornamented, the ornament consisting of strong

transverse ridges, which, where crossed by the longitudinal ridges, are broken up into bead-like prominences. The fixed and the movable tergum have this bead-like ornament only on the apico-basal ridge, the longitudinal ridges being absent on the remainder of the valve. On the movable scutum the longitudinal ridges are prominent only near the occludent margin.

*Rostrum* widely semiconical, wider than the carina, bowed inwards, its apex not freely projecting, and the lateral portion slightly more produced on the rostro-lateral side, on which the transverse arrangement of the ornament is pronounced.

*Carina* subtriangular, bowed outwards, moderately convex transversely, the apex freely projecting; a short distance from the carino-lateral margin and extending from the apex, is a prominent longitudinal ridge formed by the valve being folded along this line.

*Fixed scutum* (Pl. I. figs. 1 *a*, *b*) subtriangular, apex acuminate, considerably convex transversely, with a wide submedian fold or ridge extending from the apex; on the occludent side of the ridge the growth-lines are upturned, and on the tergal side almost straight; occludent and basal margins convex; tergal margin concave. On the inner surface a comparatively wide portion of the valve near the occludent and tergal margins is marked with growth-lines which meet on a raised ridge below the apex; this ridge serves for the reception of the scutal angle of the tergum. The pit for the adductor muscle takes up a considerable portion of the lower half of the valve.

*Fixed tergum* (Pl. I. figs. 4 *a*, *b*) subrhomboidal, considerably convex transversely, with a flat-topped apico-basal ridge which widens gradually downwards, and on this ridge the transverse ridges are broken up into small bead-like prominences owing to the crossing by the longitudinal ridges; basal margin acutely to broadly rounded. On the inner surface the apical portion is marked with growth-lines for about one-fourth the extent of the valve.

*Lateral valves*.—The two lateral valves seen in the complete specimen from Watford are somewhat broken, and as already stated, I am uncertain whether the three isolated valves are identical with them, or whether they belong to the species described (p. 952) as *Scalpellum vimineum*, sp. n. The two right valves, considered to be rostral-latera, are obliquely triangular in shape and considerably convex transversely. One (Pl. I. figs. 9 *a*, *b*) has the inner surface near the rostral margin marked with growth-lines to a greater extent than in the other valve (Pl. I. figs. 8 *a*, *b*). The latter differs also in the direction of the transverse ridges on the outer surface, for along a line extending from the apex near to the rostral margin, the transverse ridges are not continuous but bend abruptly but slightly upwards and then downwards to the margin. The right valve, regarded as a carinal-latus (Pl. I. figs. 7 *a*, *b*), is subtriangular in shape and very gently convex transversely. On the inner surface the basal

fourth of the valve only was covered by the corium, the upper three-fourths being marked with growth-lines, which indicate that the valve freely projected to that extent.

*Movable scutum* (Pl. I. figs. 2, 3 *a*, *b*) an acute-angled isosceles triangle, slightly bowed towards the tergum, but more so away from the opposing scutum; basal and tergal margins almost straight; occludent margin convex. On the inner surface a narrow portion of the valve along the occludent edge is thickened, and a shallow pit for the adductor muscle is situated about the middle of the valve. On the tergal side the inner edge is raised, and between it and the outer edge is formed a narrow groove for the reception of the tergum.

*Movable tergum* (Pl. I. figs. 5 *a*, *b*, 6) of an elongate diamond shape, almost flat transversely, with a sharp-edged apico-basal ridge; carinal margin formed of two lines making an obtuse angle; scutal angle slightly protuberant.

*Affinities of the Genus*.—From a phylogenetic standpoint *Proverruca* is by far the most important fossil Cirripede that has yet been discovered, for it serves in a most remarkable manner to link up the hitherto distinct families Pollicipedidæ and Verrucidæ.

The family Verrucidæ consists of only the single genus *Verruca*, but the genus includes some 48 species. Of these, two occur in the Upper Cretaceous (Upper Senonian and Danian), five are confined to Tertiary rocks (Miocene and Pliocene), and there are 41 recent species, of which one occurs also in the Pliocene. The shell of *Verruca* is very peculiar, since it is quite asymmetrical owing to the unequal development of the valves. There are six valves, and Darwin\* has shown by tracing the development of the young shell that they consist on one side of the carina and rostrum unequally developed on their two sides, on the other of a tergum and scutum most peculiarly modified and immovably interlocked to form the "wall" with the rostrum and carina, and a scutum and tergum in their normal and movable condition forming the top of the shell. Both Darwin† and Gruvel‡ have shown that at the first period of calcification the valves are almost symmetrical, but during the subsequent growth of the shell become more and more unequally developed to form the asymmetrical shell typical of the Verrucidæ. It is interesting also that it appears to be a matter of chance whether it is the right- or left-hand scutum and tergum that are modified to form the wall with the rostrum and carina.

*Proverruca* is of a much more primitive structure than *Verruca*, and although the valves are disposed to form an asymmetrical shell as in *Verruca*, with the exception of the inequality in size of the fixed and movable scuta and terga, the valves have

\* 1854. Ray Soc. Monogr. Sub-class Cirripedia, Balanidæ and Verrucidæ, p. 498.  
1855. Palæont. Soc. Monogr. Foss. Balanidæ and Verrucidæ, p. 41.

† 1854. Ray Soc. Monogr. Sub-class Cirripedia, Balanidæ and Verrucidæ, p. 497.

‡ 1905. 'Monographie des Cirrhipèdes ou Thécostracés,' p. 170.

undergone very little modification in structure from an ordinary pedunculate Cirripede. The fixed scutum and tergum have a greater transverse convexity than in an ordinary pedunculate Cirripede, but, unlike those of *Verruca*, they can be readily identified. In fact, they prove the correctness of Darwin's interpretation of the valves in *Verruca* as deduced from a study of the valves of the young shell. As is shown by the right and left movable scuta and terga, it is a feature of both genera that either the right or left valves may be developed to form the "wall."

If we take such a pedunculate Cirripede as is included in the sub-genus *Scillalepas* of the genus *Calantica*, we see that the capitulum is composed of two whorls of valves, the upper comprising paired scuta and terga, and a carina, the lower whorl consisting of three pairs of latera, a rostrum, and a sub-carina. There is no upper lateral valve between the scutum and tergum, although the median lateral valve may be homologous with the valve that becomes an upper lateral valve in the more specialized forms of *Scalpellum*. Now if we imagine the almost equal development of the rostrum and carina, and the suppression on one side of the lateral valves, the scutum and tergum would be allowed to form that side of the wall, and the opposing scutum and tergum would have to lean over at a greater angle to meet them. We should then have only to suppress the sub-carina, the median latus, and the peduncle, to get a form such as *Proverruca*. This was evidently the history of the form, and although *Scillalepas* may not have been the actual ancestor, it must have been a form somewhat similar. *Proverruca* still retains the primitive structure of the valves, as is shown by the isolated examples, and the two lateral valves, regarded as homologous with the rostral- and the carinal-latus in the Pollicipedidæ, are two that remain of the three lateral valves. It is of much significance that of these two valves only the carinal-latus really forms that part of the wall between the rostrum and carina. The rostral-latus overlaps for its whole length the lateral portion of the rostrum, and it certainly seems as though with the approaching attachment of the lateral portions of the rostrum and carina, the two lateral valves were on their way to suppression. We have only to imagine their absence, the meeting of the rostrum and carina, and the development of interlocking ribs to strengthen the attachment of the valves, to turn *Proverruca* into a typical *Verruca* (text-fig. 1, A, B.)

We see that in the non-attachment of the rostrum and carina, the presence of two lateral valves, and in the structure of the fixed scutum and tergum, *Proverruca* is related to the Pollicipedidæ, but more particularly to the genus *Calantica* Gray. In the asymmetry of the shell owing to the unequal development of the valves on both sides, and in one of the scuta and terga forming the operculum, it is related to *Verruca*, and it is especially near to the recent deep-sea species with elevated shells. *Proverruca* undoubtedly represents the ancestral type from which has arisen the

recent group of asymmetrical sessile Cirripedes forming the family Verrucidæ, and in its structure clearly shows its origin from the symmetrical pedunculate forms of the family Pollicipedidæ. It presents further evidence that the sessile condition has been arrived at independently on several different lines of descent during the evolution of the Cirripedia. The Verrucidæ have a phylogenetic history widely different from that of the Balanidæ (*sensu lato*), and evidence is not wanting to show that the Balanidæ also are at least diphyletic. The Chthamalinæ have almost certainly arisen from some such form as *Brachylepas*, while it is extremely difficult, if not impossible, to derive the Balaninæ from that source, or indeed from any form as yet known.

### Family POLLICIPEDIDÆ.

SCALPELLUM VIMINEUM \*, sp. n. (Pl. I. figs. 10-12.)

*Diagnosis*.—Scutum subtrapezoidal, with no apico-basal ridge, the apex rounded, the growth-ridges arranged in concentric lines from the apex; occludent margin forming a right angle with the basal margin.

*Material*.—Portions of a right and a left scutum, and a complete right tergum which might or might not belong to the same species.

*Holotype*.—The left scutum (figs. 10 *a*, *b*).

*Horizon and locality*.—Lower Senonian, upper part of *M. cor-testudinarium*-zone: Slines Oak Pit, Worms Heath, Woldingham, Surrey.

*Measurements*.—Length of left scutum, 2.9 mm.; length of left tergum 1.9 mm., breadth, 1.2 mm.

*Scutum*.—The left valve (Pl. I. figs. 10 *a*, *b*), which is more nearly complete, has the tergo-lateral portion almost entirely broken away, and is gently convex transversely. When complete the valve was subtrapezoidal in outline, and there is no apico-basal ridge. Apex rounded; basal margin convex, and forming a right angle with the lower part of the convex occludent margin. Outer surface ornamented with a number of concentric ridges terminating each zone of growth, and these ridges are broken up into bead-like prominences where crossed by the longitudinal ridges. The middle portion of the valve has the bead-like prominences much more numerous and crowded. A wide portion of the inner surface on the occludent side, and so far as preserved on the tergal side, is marked with growth-lines which meet on a raised ridge below the apex. A deep pit for the adductor muscle is situated in the middle of the basal portion of the valve.

*Tergum* (Pl. I. figs. 12 *a*, *b*) subrhomboidal, with a delicate apico-basal furrow; apex slightly curled towards the scutum, basal portion narrow and pointed. Upper carinal margin slightly

\* *vimineus*, made of wicker-work.

convex, a little shorter than the lower margin, which is straight; occludent margin extremely short, and the scutal angle much rounded and protuberant; the valve is depressed near the scutal angle, and forms a ridge parallel to the margin. Outer surface ornamented with delicate transverse ridges.

*Remarks and Comparison with other Species.*—These three valves were found with those of *Proverruca vinculum*, already described (p. 946), but there is no evidence to show that they belong to one individual. The scutum is ornamented like the valves of *P. vinculum*, but it differs so much from the homologous valve of that species that I refer it to a new species, and to the genus *Scalpellum* (*sensu lato*). The small transverse convexity of the valve seems to preclude the possibility of its having formed part of a shell as is the case in *Proverruca*, and therefore representing a second species of the genus. Its structure renders it more probable that it formed part of a capitulum of a pedunculate Cirripede of the genus *Scalpellum*, but further information is needed as to the remaining valves before anything more definite can be said regarding the relationship of the species.

The scutum differs from that of *Proverruca vinculum*, mainly in its much less triangular shape, in the occludent and basal margins forming an angle of  $90^\circ$  instead of about  $45^\circ$ , and in the absence of an apico-basal ridge. The tergum differs chiefly in the presence of a delicate apico-basal furrow, instead of a prominent ridge.

My thanks are due to Dr. F. A. Bather, Dr. W. T. Calman, and Mr. C. P. Chatwin for help in connexion with this paper.

#### EXPLANATION OF THE PLATE.

##### *Proverruca vinculum*, gen. et sp. n.

Lower Senonian, Upper part of *M. cor-testudinarium*-zone: Slines Oak Pit, Worms Heath, Woldingham, Surrey.

- Fig. 1. Fixed scutum. *a*, outer view of left valve; *b*, inner view.  
 2. Movable scutum. Outer view of a comparatively wide left valve.  
 3. Movable scutum. *a*, outer view of left valve; *b*, inner view.  
 4. Fixed tergum. *a*, outer view of left valve; *b*, inner view.  
 5. Movable tergum. *a*, outer view of left valve with basal portion broken away; *b*, inner view.  
 6. Movable tergum. Outer view of smaller but more complete left valve.  
 7. Carinal-latus. *a*, outer view of right valve; *b*, inner view.  
 8. Rostral-latus. *a*, outer view of incomplete left valve; *b*, inner view.  
 9. Rostral-latus. *a*, outer view of nearly complete left valve; *b*, inner view.

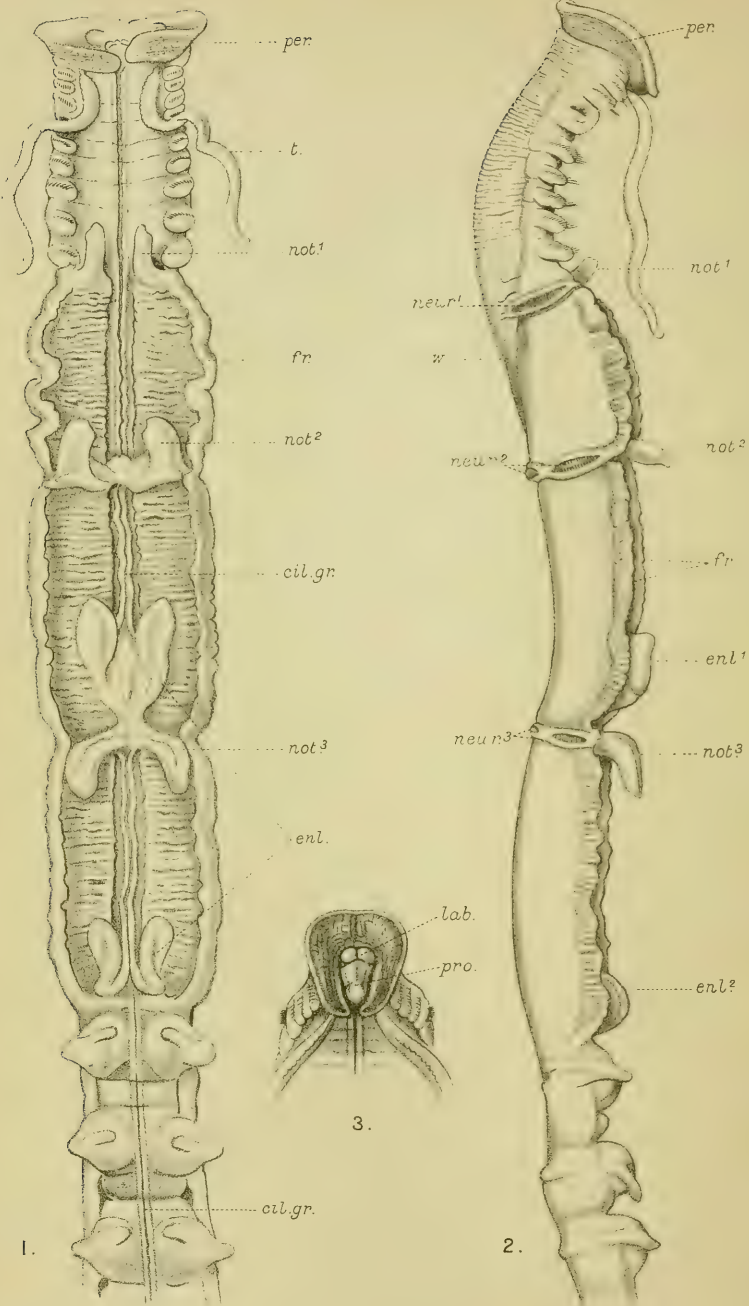
##### *Scalpellum vimineum*, sp. n.

10. Scutum. *a*, outer view of left valve of which the tergal portion is broken away; *b*, inner view.  
 11. Scutum. *a*, outer view of fragment of a right valve (portion near rostral angle) with very pronounced ornament; *b*, inner view.  
 12. Tergum. *a*, outer view of complete right valve; *b*, inner view.

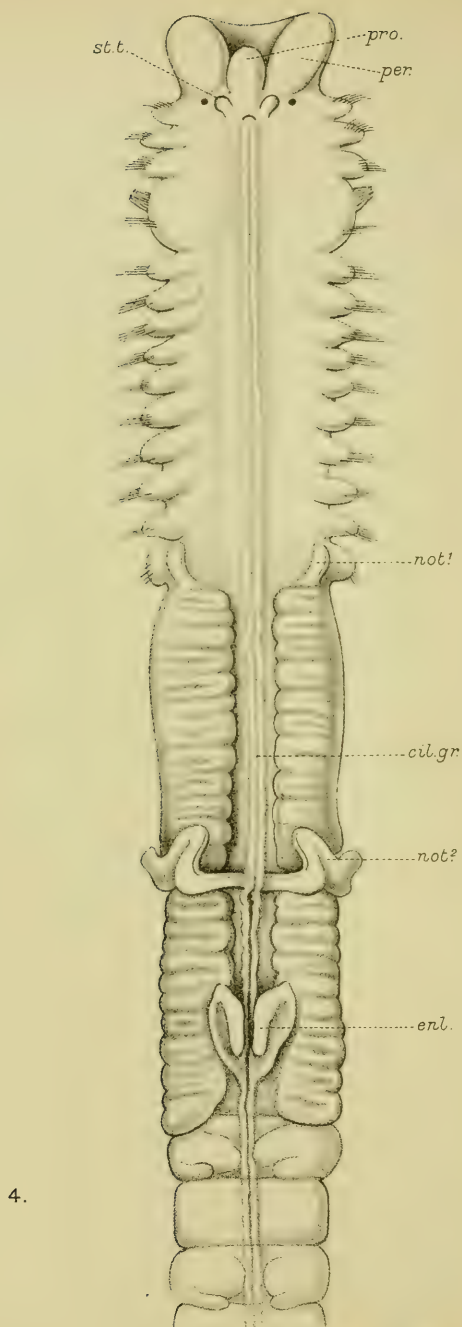
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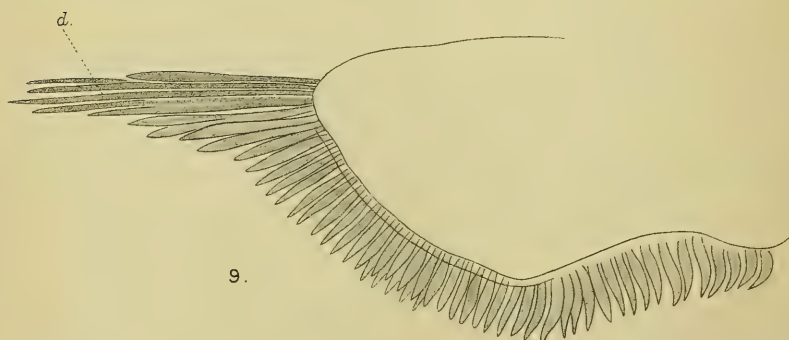
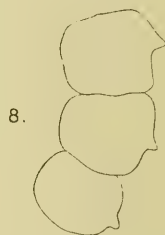
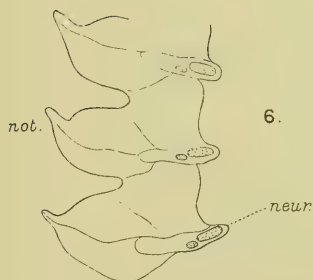
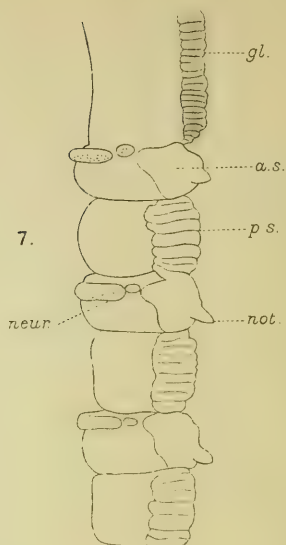
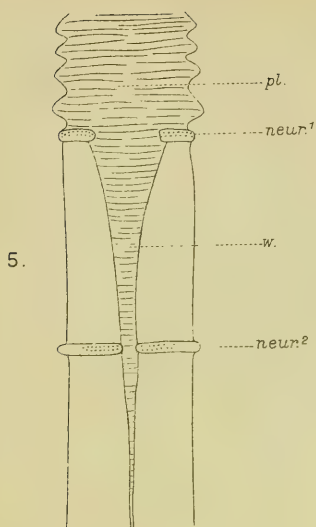




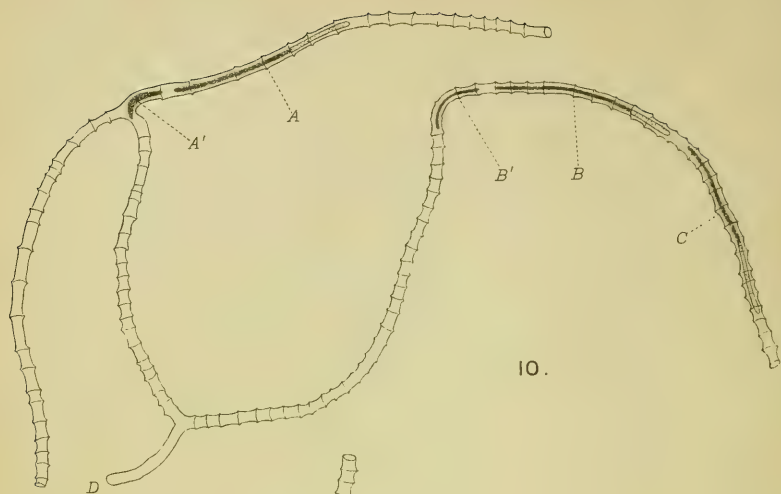




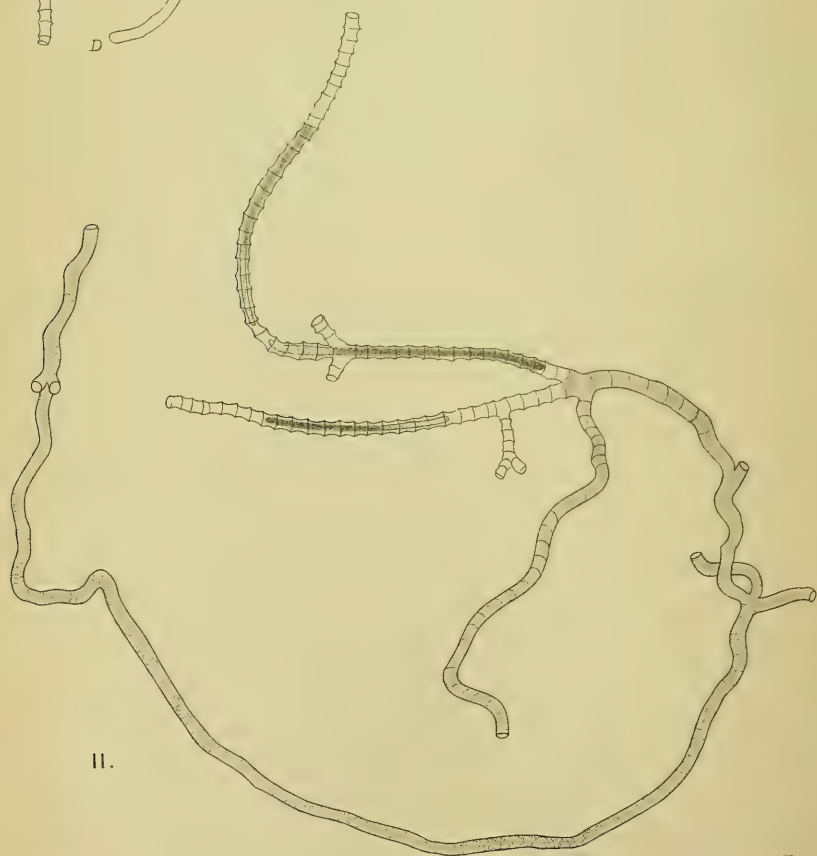






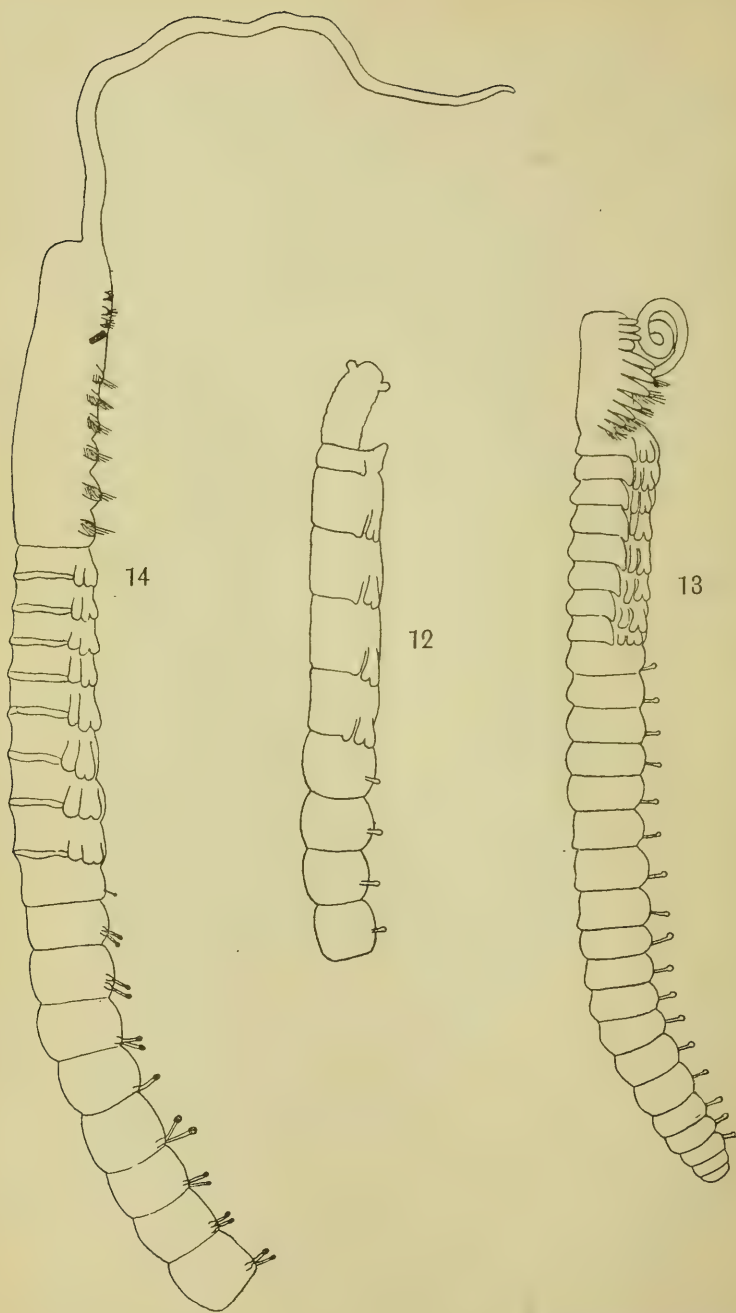


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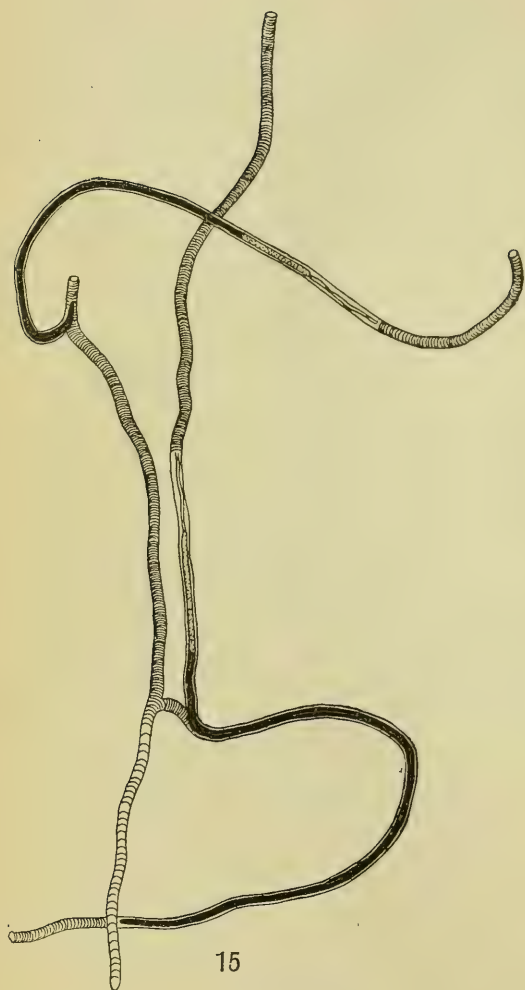




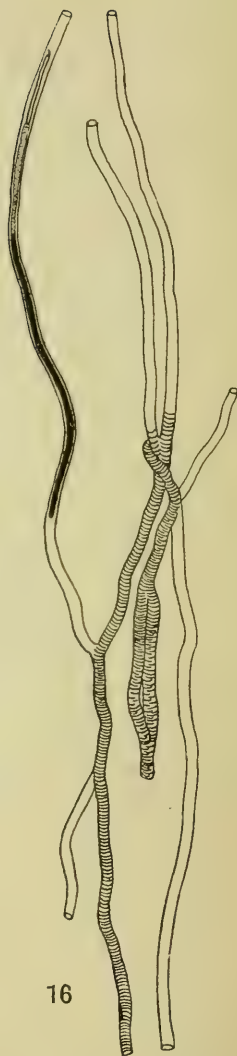
Cambridge University Press.

PHYLLOCHAETOPTERUS PROLIFICA.





15



16

51. Polychæta from the N.E. Pacific : The Chætopteridæ. With an Account of the Phenomenon of Asexual Reproduction in *Phyllochætopterus* and the Description of Two new Species of Chætopteridæ from the Atlantic. By F. A. PORTS, M A., Fellow of Trinity Hall, Cambridge, and Balfour Student of the University\*.

[Received May 30, 1914; Read November 24, 1914.]

(Plates I.—VI.† and Text-figures 1–13.)

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## INTRODUCTION.

The Chætopterids found in the coastal waters of the Gulf of Georgia and Puget Sound, though the species are few in number, are very widely distributed and remarkably interesting in their biology and morphology. My observations were made on three species, all of which appear to be new :—

*Mesochætopterus taylora*, gen. et sp. n.

*Phyllochætopterus prolifica*, sp. n.

*Telepsavus* sp.

Of these *Mesochætopterus* partly bridges the gap between the remarkable form *Chætopterus* and the other members of the family. *Phyllochætopterus prolifica* possesses a type of asexual reproduction which is now described for the first time in the Polychæta‡. *Telepsavus* is a genus hitherto only known

\* Communicated by the SECRETARY.

† For explanation of the Plates see p. 993.

‡ A preliminary note on this phenomenon was published in Rep. Brit. Assoc. Adv. Science, 1912, Dundee, p. 513.

to occur in the Mediterranean and the Red Sea. In previous collections the Chætopterids appear to have been represented only by empty tubes, and their interest has remained unsuspected (*cf.* Johnson, "The Polychæta of the Puget Sound Region," Proc. Boston Soc. Nat. Hist. vol. xxix. p. 386).

The collections, of which the worms described here form a part, were made in the summer of 1911, while I was a guest at the Biological Laboratory at Departure Bay, Vancouver Island, which is maintained by the Dominion Government. I should like to express my heartiest thanks for the hospitality extended to me there. The tidings of the death of the Rev. G. W. Taylor, the first Director of the Station, reached me here last year (1912), and I wish to place on record some slight tribute to the memory of one of the pioneers of marine biology in British Columbia. His enthusiasm for the study of the rich fauna of the Pacific Coast, and the patient care which he bestowed upon its investigation are worthy of great praise. I only knew him in the last year of his life, during a time when, crippled by paralysis, he suffered greatly, but his kindness and thoughtfulness will always remain a pleasant memory to me.

In connection with my work in Canada, I wish, too, to gratefully acknowledge my indebtedness to the Managers of the Balfour Fund, who made me a special grant to assist in defraying the expenses of the journey.

Of the other forms which are described in this paper, *Mesochætopterus minuta* was found amongst the collection made by Mr. Cyril Crossland in the Cape Verde Islands during July and August 1904. I am much obliged to him for permission to describe this form, and for his kindness in reading through this paper. Lastly, the new species of *Phyllochætopterus*, which I have found to be an inhabitant of British waters, was obtained while working at the Laboratory of the Marine Biological Association at Plymouth in the spring of 1913.

#### Family CHÆTOPTERIDÆ Audouin and Edwards.

*Polychæta* inhabiting a tube of parchment-like consistency and very closely adapted to their tubicolous life. Body divided into two, or sometimes three, distinct regions. Prostomium small, often bearing eyes; peristomium forming a collar, with two tentacles more or less developed. The first (anterior) region is composed of a small and fairly constant number of segments; of the two divisions of the parapodium the notopodium only is developed. The segments behind this region have biramous parapodia; the variation of the notopodia here affords the chief method of differentiating between the genera of the family. Generally two distinct types are successively met with in the same animal, thus enabling us to distinguish second (median) and third (posterior) regions. Throughout the body the notopodia carry capillary setæ; in the fourth segment one or more are much stronger and thicker than

the rest. Each neuropodium consists of a double ridge, with several rows of uncini. The dorsal surface is greatly flattened in the anterior region, and carries a median ciliated groove, which runs the whole length of the body in some forms, but is interrupted in others.

### Table of Genera.

- (a') All segments behind anterior region similar.
- (b') Notopodium of posterior segments unilobed ..... *Ranzania*
- (b'') Notopodium of posterior segments bilobed ..... *Telepsarus*.
- (a'') Median and posterior regions both present.
- (c') Segments in median region with bilobed foliaceous notopodia, each carrying several capillary setæ.
- (d') Number of segments in median region variable ... *Phyllochætopterus*.
- (d'') Two segments in median region ..... *Spiochætopterus*.
- (c'') Segments in median region typically with unilobed notopodia. Peristomial collar well developed.
- (e') Median segments two or three in number; notopodia all conical in shape; tentacles long ..... *Mesochætopterus*.
- (e'') Median segments five in number; first with separate aliform notopodia; others with notopodia fused to form fans or suckers; tentacles short... *Chætopterus*.

### MESOCHÆTOPTERUS, gen. n.

*Chætopterids with a well-developed peristomial collar and a pair of long peristomial tentacles. Body divided into three regions. The anterior contains 9-13 setigerous segments; the parapodia are represented by short and conical notopodia with capillary setæ; in the fourth setigerous segment several of the dorsal setæ are enlarged. The median region is composed of 2 or 3 elongated segments, forming dorsally a flat region, with continuous lateral borders, covered with glandular epithelium and ornamented with transverse ridges. Typically the notopodia are rather enlarged, conical, and fleshy, with a groove running down the inner border; the neuropodia are single in the first, double in the succeeding segment or segments, and contain uncini. The posterior region contains a large number of segments similar to those in Chætopterus, but with much shorter notopodia. A dorsal ciliated groove runs from the mouth along the median line to the posterior end. In one or more of the median segments the lips are enlarged to form a fleshy organ.*

The genus thus agrees with *Chætopterus* in the reduced number and specialised character of the segments of the median region. It resembles *Phyllochætopterus* in the continuous ciliated groove and the long tentacles.

### Diagnoses of Species of Mesochætopterus here described.

*M. taylori*, sp. n.—A long but slender Mesochætopterus, living in a long narrow unbranched tube of opaque parchment, embedded for the most part vertically in sand and ending blindly. Prostomium very small, without eyes, entirely surrounded and hidden by the well-developed peristomial collar. The anterior region contains 9 or

10 setigerous segments. The median region is composed of 3 segments; in all, the notopodia are of the type described in the diagnosis of the genus. The posterior region contains a large number (about 60) of segments; the short notopodia each with several capillary setae.

*Locality.* Pacific coast of North America.

*M. minuta*, sp. n.—A very small slender Mesochætopterus, living in tubes of a translucent horny material coated with coarse sand. Prostomium large and conical; peristomial collar well developed, but not so complete as in *M. taylori*. Just external to the tentacles is a pair of eyes. The anterior region contains 10–13 segments. The median region is composed of 2 segments; the first pair of notopodia are small and clavate, the second pair are of the type described above for the genus. The ciliated groove is expanded into a cup in the middle of the second median segment. The posterior region is composed of segments which are double anteriorly, single posteriorly; each notopodium has a single seta.

*Locality.* Cape Verde Islands, Atlantic; Torres Straits, Pacific.

MESCHÆOPTERUS TAYLORI, sp. n. (Plates I., III., figs. 5, 6, 9; Text-figs. 1–5.)

*Occurrence and Habits.*—This animal was first found in Departure Bay, near Nanaimo, Vancouver Island, on a wide stretch of sandy beach, which was partly bare and partly covered with beds of *Zostera*. Over the whole area, from the middle of the beach to the lowest tide-mark, there were to be found brown tubes about a quarter of an inch in diameter, lined with a brown parchment-like material, while the outer layer is membranous and coated externally with sand-grains. The tubes, which project very slightly above the surface, are not U-shaped as in *Chaetopterus*, but go straight down through the sand generally for about eighteen inches. On reaching the shingle underneath they sometimes turned and ran horizontally. In one case, where especial care was taken to obtain the tube whole and uninjured, it was found to end blindly in a neatly rounded apex. The last part was much thinner, without the parchment lining. The total length of the tube in this case was three feet. It is, as a rule, however, very difficult to obtain the entire tube, owing to the fact that the sand is deeper in most places and the tube runs vertically through its whole extent. But without obtaining the whole tube it is almost impossible to examine entire specimens of its inhabitant, which rapidly retreats to the depths of its dwelling as soon as the spade strikes the sand. Most of the individuals collected consisted only of the first two regions.

Later the animal was dredged in two or three fathoms of water at Nanoose Bay, and also observed on sandy beaches, between tide-marks, at Victoria on the south end of Vancouver Island and Olga in the San Juan Archipelago, just over the

International Boundary. It is thus widely distributed in the neighbourhood of Puget Sound and the Gulf of Georgia.

One whole specimen was obtained with the following dimensions:—

Length 28.5 cm. Width in broadest part 1 cm.

Anterior region with 9 segments 1.8 cm. long.

Median region with 3 segments 4.0 cm.

Posterior region with 68 segments 22.7 cm.

This was probably a small individual, since in others measured the anterior and median regions exceeded the figures given above.

*Mesochætopterus* is a longer and much more slender worm than *Chætopterus variopedatus*. The delicacy and transparency of the integument, which is so marked a feature of the last-named species, is not characteristic of the new genus. The whole surface is a creamy white or yellow, relieved by dashes of chocolate pigment on the peristomium and tentacles alone. In the posterior region the dark green gut shows through the body-wall. The ventral musculature is, throughout the body, more developed than in *Chætopterus*.

The *prostomium* (Pl. I. fig. 3) is a small rounded prominence with unpigmented skin. It is much more distinct than in *Chætopterus*. There is no trace of eyes. The *peristomium* forms a prominent buccal funnel which entirely surrounds the prostomium. It is, however, shallower, with more gently sloping sides than in *Chætopterus*. As mentioned above, there is here a noticeable development of the chocolate pigment, which does not dissolve in alcohol, and so is retained by the preserved specimens. The peristomial tentacles originate just outside the peristomial collar. They are stout grooved structures (very extensible in the living animal) and measuring, even in their contracted state, 3–4 cm. They contain a pigment similar to that mentioned above. The *mouth* is situated between the prostomium and the ventral lip of the peristomium, and is bordered in some specimens by two rounded lips below.

The *anterior region* is convex on the ventral side, concave on the dorsal. It differs, however, generally from that of *Chætopterus*, firstly in the narrower width and secondly in the shortness of the notopodia. In 21 specimens examined, 10 had 9 segments, an equal number had 10 segments, and a single individual 11. In *Chætopterus variopedatus*, similarly, though 9 is the typical number, Joyeux Laffuie observed individuals with 10, 11, and even, in one case, 12 segments. The parapodia of the anterior region are all similar and represented by the conical notopodia, which increase slightly in size as we pass posteriorly. The dorsal curvature is not so distinct as in *Chætopterus*. The last segment does not bear an appendage representing the neuropodium, such as occurs in *C. variopedatus* (Joyeux Laffuie, 9, p. 257, pl. xv. fig. 2) and other species.

In the notopodium of *Chaetopterus* there are two long straight rows of capillary setæ, embedded for the greater part of their length in the parapodium, but projecting from the surface for short but equal distances. They are all lanceolate in type, but the dorsalmost setæ differ from the rest in being slender and scarcely dilated. This tendency to differential development is greatly exaggerated in the 4th segment. The dorsal setæ preserve their slender lanceolate character, but a number of the ventral setæ become short, strong, truncated at their extremities, and black in colour. Those situated most ventrally present these characters in the highest degree (text-fig. 4 A).

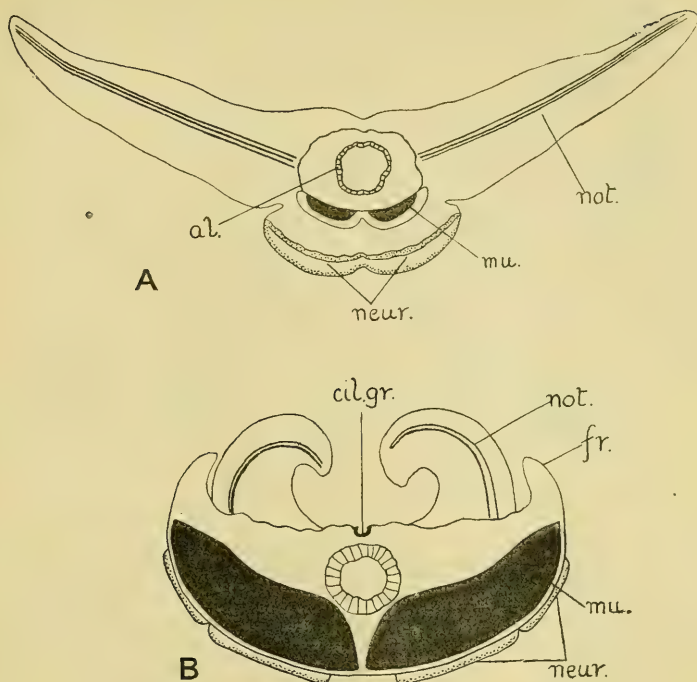
In *Mesochaetopterus* the setæ (Pl. III. fig. 9) are more delicate than those of *Chaetopterus*, and have a different arrangement, owing to the shortness of the parapodia. They are mostly of a distinct lanceolate type and equal in length, but a few of the dorsalmost are much longer and more slender, projecting in a ragged tuft from the extremity of the neuropodium. They occur in a slightly curved row. In the fourth parapodium there is a single line making a very pronounced curve. Ventrally there are about 12 modified setæ.

*Median Region.*—Though consisting of three segments only, it is much longer than the anterior region. In *Chaetopterus* the median region is characterised by the transparent nature of the body-wall and the reduced width of the segments; here every segment is of a uniform width greater than that of the anterior region, the dorsal surface is flattened and glandular, and enclosed on each side by a continuous border formed by the thin upturned edges of the segments (Pl. I. fig. 2, *fr.*), and the ventral muscles are much larger and stouter than in *Chaetopterus*.

When the animal is alive and inside its dwelling the lateral borders are approximated so as to form an imperfect tube dorsally. Their appearance in text-fig. 1 does not do justice to their extent in the living animal.

The parapodia in *Mesochaetopterus* have not undergone the great and diverse modification occurring in *Chaetopterus* (compare text-fig. 1, A, B). They resemble very closely those of the abdominal region and attain a similar development in all three segments. The notopodia are short and conical, little larger than in the abdomen; they possess an internal skeleton of two or three stout capillary setæ. They are on the distal surface and approximated to the middle line. On the inner surface they possess a ciliated groove which meets the median groove. I think that there is little doubt that they act as accessory organs for the collection of microscopic food, interrupting the dorsal channel, and separating food-particles from the current by the action of the cilia contained in these grooves. The neuropodia are slightly different in the three segments. The ventral surface of the anterior region (Pl. III. fig. 5) is entirely occupied, as in *Chaetopterus*, by a "plastron" (*pl.*) with a slightly wrinkled appearance to the naked eye and composed of high epithelial

Text-figure 1.

A. *Chaetopterus variopedatus*. B. *Mesochaetopterus taylora*.

Anterior view of median segments.

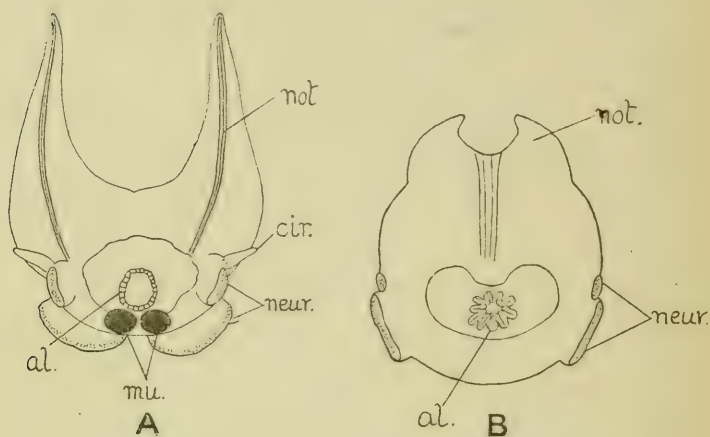
*al.*, alimentary canal; *cil.gr.*, dorsal ciliated groove; *fr.*, lateral borders; *mu.*, ventral longitudinal musculature; *neur.*, neuropodium; *not.*, notopodium with its acicular setæ.

cells. From this, along the median region, there runs a wedge-shaped prolongation (*w.*), which narrows down in the second segment to a median groove. But in the first segment it is broad, and the neuropodia are restricted to two narrow lateral strips of different appearance. Here, then, each neuropodium is a single structure; in the two succeeding segments the neuropodia are much broader, extending almost to the middle line, and are divided into a dorsal and a ventral half, the former being slightly smaller and pushed a little forward. Each contains several rows of uncini. There is no indication whatever of the fusion of the neuropodia to form a sucker-like median structure, which occurs in *Chaetopterus*. A typical uncinus of this region is figured in text-figure 3.

The dorsal surface of the median region is covered by glandular epithelium, raised into transverse furrows.

*Posterior Region* (text-fig. 2).—In the one complete animal which I obtained this contained 64 segments, a much larger number than has ever been observed in *Chaetopterus* (Joyeux

Text-figure 2.



A. *Chaetopterus naniopedatus*. B. *Mesochaetopterus taylora*.

To show difference in form of typical segments of the posterior region.

*cir.*, cirrus-like appendage of the neuropodium. Other lettering as in text-fig. 1.

Text-figure 3.



*Mesochaetopterus taylora*.  $\times 325$ .  
Uncus from first segment of median region.

Laffaie; 9, gives 27-40). The segments differ from those of the median region chiefly in their shorter length. The whole region has the appearance of a string of beads, each segment being rounded and connected with its fellows only by a narrow neck, through which run the intestine and the nerve-cord (Pl. III. fig. 6). The rounded appearance is due to the very much swollen portion of the segment which contains the generative organs. The two notopodia have coalesced for a considerable part of their length, so that the free portions are very short indeed. In them are contained several (about 8) capillary setae. The neuropodia constitute a continuous narrow ridge half encircling the segment; it bears on each side two uncinigerous tori, which are, however, by no means so well developed and independent as is the case in *Chaetopterus*. The dorsal torus is a little smaller and placed rather more anteriorly.

The small cirrus-like appendage (*cir.*) found just outside the dorsal torus in *Chaetopterus* is not present in *Mesochætæpterus*.

MESOCHÆTOPTERUS MINUTA, sp. n. (Plates II., III. figs. 7, 8; Text-figs. 4, 5.)

*Occurrence.*—This species was found twice by Mr. Cyril Crossland during his visit to the Cape Verde Islands in August and September, 1904, once at St. Vincent, and again at Porto Praya. On the first occasion tufts of tubes were collected on the shore (? amongst sand) at low tide, and on the second tubes which contained much larger specimens were found projecting from and embedded in masses of nullipores. They were associated with *Onuphis* and a species of *Spionid*. In November 1913, I found this species also at Murray Island, Torres Straits, living in sandy tubes between tide-marks. Except for their generally smaller size, these Australian individuals conform with the description which follows in all essential particulars.

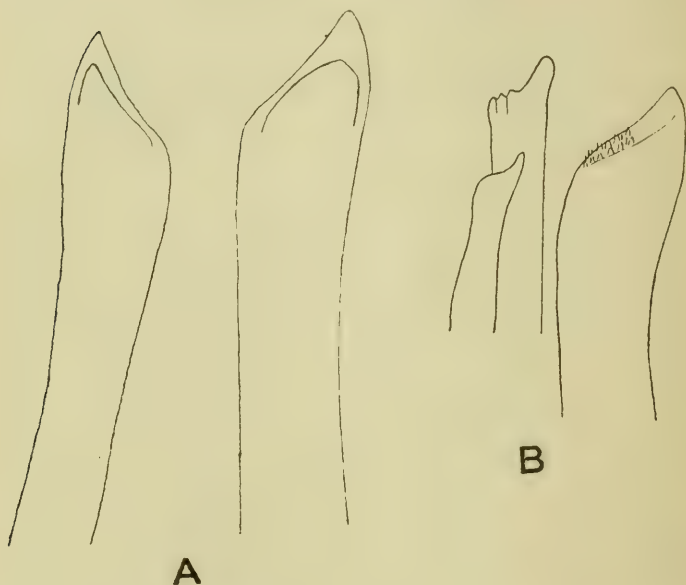
The animal is milk-white in colour, with no pigmentation, except that of the gut shining through posteriorly. None of the individuals which reached me was quite complete, but those from Porto Praya were about 2.5 cm. in length, while those from St. Vincent barely exceeded 1.5 cm. In the largest the maximum breadth was very little more than 1 mm.

The *prostomium* (Pl. II. fig. 4) is a very distinct feature, better developed than in any species of *Phyllochaetopterus* which I have been able to examine. It is conical in shape. The *peristomium* forms a deep cup like that in *M. taylori*, but not so complete owing to the size of the prostomium, and without the considerable development of pigment which occurs in the other species. At the base of the prostomium come off the two long peristomial tentacles. The eyes were only seen in the specimens from Porto Praya, in which, however, they were very distinct. They are curiously placed on the peristomium just outside the bases of the tentacles.

In the *anterior region* the number of segments is variable. In

the two larger individuals from Porto Praya there were 13 or 14 respectively; in those from St. Vincent 10 segments in most, 9 in one or two. The notopodia show differences from those in the corresponding region of *M. taylori*, due partly to the great difference in size of the two animals. In the Cape Verde species there is naturally a very much smaller number of setæ in each parapodium (about 20 or 30). The setæ themselves are easily distinguishable from those of *M. taylori* (cf. text-fig. 5) by their shorter heads. As in that species so here, dorsally they become longer and more slender, with an almost symmetrical

Text-figure 4.

A. *Mesochætopterus taylori*,  $\times 70$ . B. *Mesochætopterus minuta*,  $\times 325$ .

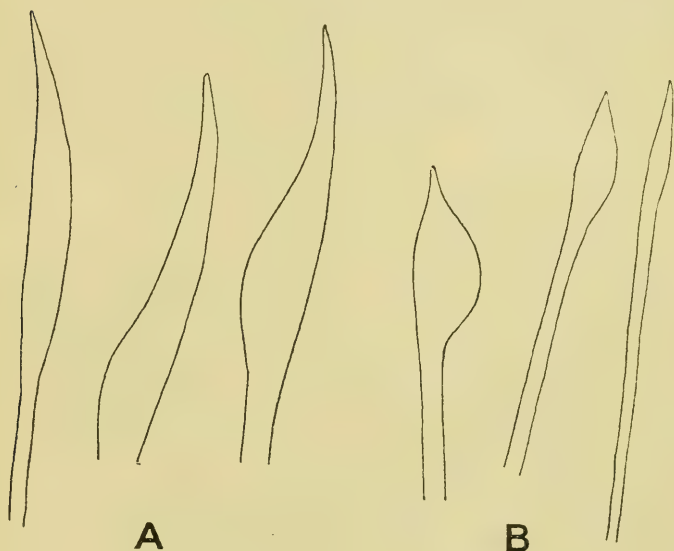
Enlarged setæ of fourth segment.

lanceolate head. The fourth segment (text-fig. 4 B) carries ventrally a number of dark brown modified setæ varying from 4 to 7. The larger ones have a distinct likeness to those of *M. taylori*, though, of course, they are much smaller. There is a tendency for the oblique edge of the seta to be fimbriated. This is apparently due, not to a natural serration, but to splitting of the fibrous chitin of the seta.

The *median region* consists of only two segments, but it is nearly twice as long as the anterior region. It is the great likeness in the configuration of the median region which shows

quite plainly that these two worms from the Atlantic and the Pacific must be placed in the same genus. In both the segments are broad and flattened, with a glandular dorsal surface raised into transverse ridges and traversed by a continuous ciliated groove. In both, too, the parapodia are similar, and there is an enlargement and incipient modification of the ciliated groove to form a cup-shaped organ. There are, of course, minor differences, namely, in the development of the notopodia of the first segment and in the presence of a rounded lateral border to the region without the thin upturned edges which are characteristic of *M. taylori*.

Text-figure 5.



Typical notopodial setæ of anterior region.

A. *Mesochætopterus taylori*. B. *Mesochætopterus minuta*.

The first segment is much longer. The notopodia are even less developed than in *M. taylori*—in fact, they are merely clavate papillæ like the second pair of peristomial appendages in *Phyllochètopterus*. In the individuals I examined there were two or three slender setæ embedded almost entirely in the notopodium, but projecting very slightly from the surface and ending in a slight lanceolate head.

The neuropodium is a single structure, separated from its fellow on the other side by a wedge-shaped prolongation of glandular tissue exactly like that described above for *M. taylori*. The uncini contained in the neuropodium are very similar to

those of the other species, though much smaller. But they have six or seven teeth, or very nearly the number which is found in *M. taylora*.

The second segment is about two-thirds the length of the first. The notopodia of this segment are exactly like those described as typical for the genus—conical and enlarged, with a groove running down the internal border towards the median groove. It contains a couple of slender acicular setæ, which do not project terminally from the parapodium as in the first segment and have no distinguishable head. The neuropodia are double structures and call for no remark.

About the middle of this segment there is an enlargement of the lips of the ciliated groove rather like those occurring in the second and third median segments of *M. taylora*. It is exceedingly interesting to notice, however, that in some individuals the lips approximate posteriorly, and an almost complete circular cup is formed like that in the 13th segment of *Chaetopterus*. This is a variable character in the species, however—in the individual figured here there is no posterior fusion of the lips. But from the variations which occur in the genus *Mesochaetopterus* we can undoubtedly see how the accessory feeding-organ in *Chaetopterus* has arisen from the ciliated groove.

The *posterior region* (Pl. III. figs. 7, 8) is composed of short rounded segments. As none of the specimens is complete, I am unable to say how many are found. Anteriorly each segment is divided into two by a slight constriction. The proximal half bears the parapodium. As in *M. taylora*, the free part of the notopodia projects very slightly from the surface. As a rule, they contain a couple of thin acicular setæ, sometimes only a single one. The neuropodia have the usual double uncinigerous torus, the dorsal part being very small.

The distal half of the segment is the part which in *M. taylora* is diminished to form the neck between successive segments.

The two species here described differ extraordinarily in size, for while *M. taylora* is the largest Chaetopterid known, *M. minuta* is probably the smallest. I shall have occasion to remark upon the great variation which occurs in the development of the prostomium in the genus *Phyllochaetopterus*, but in this respect these two species differ still more widely. But while *M. minuta* resembles many species of *Phyllochaetopterus* in the character of the prostomium, the peristomial collar is deeper and better developed than is ever the case in the latter genus, and the second pair of peristomial appendages—which are so characteristic of *Phyllochaetopterus*—are, I think, absent here. These two circumstances are, I believe, connected. Then, again, the number of segments comprised in the median region is quite constant, but different in the two species—two in *M. minuta*, three in *M. taylora*,—and this draws another very definite distinction. There are other differences, which I have mentioned above. Some of these, *e. g.* number and shape of setæ, are partly dependent

upon the differences in size of the animals. Speaking generally, however, these two species are far more definitely distinguishable than any pair of species in *Phyllochaetopterus* or in *Chaetopterus*.

No less interesting than the diversity in form of the two species is their curious distribution. While *M. taylori* is so far only known to occur in the coastal waters of the N.E. Pacific, *M. minuta* has already proved to have a much more extended range. The type-specimens come from the subtropical regions of the North Atlantic, but I was surprised to find a *Mesochaetopterus* of common occurrence in Torres Straits, which is, without doubt, identical with *M. minuta*. It will prove, I venture to predict, a widely spread Indo-Pacific form, and its absence from previous descriptions only illustrates the difficulty of obtaining a representative idea of a Polychæt fauna from general collections. Though *M. minuta* may be found in the Indian Ocean, it is less likely to turn up in the Red Sea and the Mediterranean, where so much attention has been given to the obscurer forms of Polychæt worms, and the distribution will probably remain discontinuous in type.

#### *The Position of Mesochaetopterus in the Family.*

It can hardly be doubted that a close relationship exists between *Chaetopterus* and *Mesochaetopterus*. The structural differences between them correspond closely with the different kinds of tubes which they occupy. *Chaetopterus* possesses a much wider tube, in which it fits very loosely, and it is for this reason that the excessive and bizarre modifications of the median region have been produced. Adhesive organs are needed to maintain the position of the worm in the tube, and these are formed by the fusion of the notopodia giving a cup-shaped sucker. Ciliary action alone would be too feeble to produce an efficient circulatory current in so wide a space, and hence the fans of the 14th-16th segments exist. The notopodia of the anterior and posterior regions are concerned in the movement of the animal up and down in its tube. They must be long enough to touch the walls and so attain to much greater dimensions than in *Mesochaetopterus*. The greater or lesser length of the parapodia causes, as we have seen above, some difference in the arrangement of the setæ.

*Chaetopterus* possesses, too, a complicated method of feeding, which is responsible for further differentiation in its external structure. This method has been lately described by Enders in detail (4). The long aliform notopodia of the 12th segment and the dorsal cup of the 13th segment alike aid in separating food from the respiratory current, and compacting it into masses which are swept forward in the ciliary groove to the mouth. The middle region, then, fulfils a double function in promoting the circulation of water in the tube and collecting food, different segments being specialised for each task. In consequence of this

division of labour, a number of segments is included in the region, larger than in *Mesochaetopterus*.

I have not found it possible, in the absence of experimental observations, to reach any such clear conclusions as to the functions of the different organs of *Mesochaetopterus*. Food is partly collected by two long grooved tentacles, which are constantly projecting from the mouth of the tube and sweeping over the surface of the sand in search of small fry. Enders makes a similar observation on another Chaetopterid with long tentacles, to which he applies the name *Spiochaetopterus oculatus*? He describes it as scraping with its tentacles the sides of the aquarium in which it was kept; the diatoms thus dislodged were swept up the ciliary grooves of the tentacles into the mouth. Nutritive particles are, no doubt, also collected by the action of the cilia of the buccal funnel as in *Chaetopterus*, and, lastly, I think, the notopodia of the median region have a similar function to those of the 12th segment in the above-mentioned worm. A branch of the median ciliated groove runs along the inner surface of each of them, and in my view such minute organisms as are not strained from the circulating sea-water anteriorly are here arrested by the parapodia, mixed with mucus secreted by the glandular epithelium of the surface and swept into the median groove and along to the mouth.

The ciliated groove in *Mesochaetopterus*, as in *Phyllochaetopterus*, is quite continuous in its course from the head to the tail. The primary function of such a groove is to maintain a respiratory current through the tube, as is well seen in forms with a transparent dwelling like *Phyllochaetopterus prolifica*.

In *Chaetopterus*, owing to the development of the respiratory fans, the ciliated groove does not extend farther back than the 13th segment and has changed its function, being now employed in the collection of food. We may well suppose that in *Mesochaetopterus* the action of the cilia causing a flow of water from head to tail is not continuous, but is reversed on occasion to carry food back to the mouth.

*Chaetopterus* is without doubt the form most specialised in structure in the family, and this is shown not only by the modifications of the median region but also in the discontinuous ciliated groove and the shortness of the tentacles. It is impossible to agree with Enders, who supposes that the long tentacles of *Spiochaetopterus* "have undergone a considerable specialisation" and speaks of the shorter tentacles of *Chaetopterus* as more primitive than those of *Spiochaetopterus*.

The group of Chaetopterids, which includes *Ranzania*, *Phyllochaetopterus*, *Telepsavus*, and *Spiochaetopterus*, are distinguished by possessing long tentacles (the most important organs in procuring food) and a complete ciliated groove. A differentiation of the median from the posterior region is sometimes not found at all (*Telepsavus*, *Ranzania*). If it occurs, the number of segments in the median region is very variable (in species and even in

individuals), and they differ very little from the abdominal segments. But the other two points are, without doubt, primitive characters, and the long tentacles (but not the ciliated groove) are shared with the Spionids.

*Mesochætopterus* forms the connecting-link between these primitive forms and the specialised *Chætopterus*.

In the possession of long tentacles and a continuous ciliated groove it resembles *Phyllochætopterus*. In the development of a very distinct median region composed of a small number of segments with grooved notopodia, which possibly assist in the collection of food, it comes near to *Chætopterus*.

#### TELEPSAVUS Gabr. Costa.

Only two species of this genus have been described hitherto: these are *T. costarum* Claparède, from Naples (1), and *T. bonhourei* Gravier, from Djibouti in the Red Sea (5).

#### TELEPSAVUS sp. (Text-figs. 6-8.)

Though this Polychæt is a very common and widely distributed member of the beach fauna of British Columbia, my collection contains only one specimen which is at all well preserved, and in this the head is incomplete. Such individuals as were preserved in their tubes were quite worthless, owing to the impermeability of the material, which thus differs from that formed by *Phyllochætopterus* considerably more than their appearance seems to show. The following account of the species is thus very incomplete, and I refrain from giving a name until the species can be better defined. I should also like to state my opinion that the validity of Gravier's species is questionable until an actual comparison of the Mediterranean and Red Sea forms is made.

*Occurrence*.—On the same sandy beach at Departure Bay, which I have described in my account of *Mesochætopterus*, the tubes of a second smaller Chætopterid were discovered. They are composed of a translucent horny material and are annulated, the joints occurring at short intervals. In length they sometimes exceed a foot and a half, running vertically down through the sand and ending in a neatly rounded apex. In diameter the tube is less than 2 millimetres, the worm fitting fairly tightly within its habitation. A single individual occurs in each tube, with its long peristomial tentacles often projecting from the aperture.

The distribution of *Telepsavus* has been found to be a wide one. Generally it may be said to occur wherever *Mesochætopterus* exists. I have collected both together in Departure Bay, at Olga in the San Juan Archipelago, on Ballard Beach, Seattle, U.S.A., and by dredging in two or three fathoms of water at Nanoose Bay, Vancouver Island.

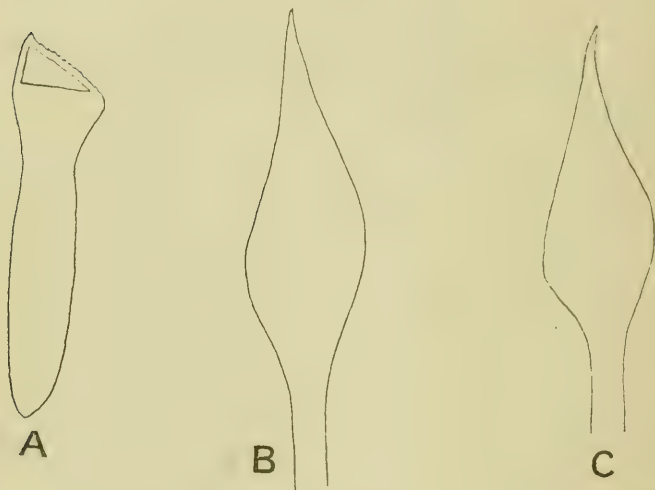
At the end of August 1911, too, I found *Telepsavus* at Skidegate in the Queen Charlotte Islands, 500 miles to the north, living in muddy gravel. Here and at Departure Bay at the

beginning of the month the female worms had well-developed orange gonads.

*Size*.—The almost complete individual measured was about 5 cm. long and nearly 2 mm. broad (*i. e.* about the same length as and rather broader than the two species hitherto described).

I cannot, unfortunately, say anything about the structure of the *head*. The *anterior region* consists of 9 segments. In my specimen the 7th, 8th, and 9th segments, but particularly the two latter, are much longer than the others. In this particular the Canadian form agrees with the description of *T. bonhourei*,

Text-figure 6.



*Telepsavus* sp.

A. Enlarged seta from 4th segment.  $\times 70$ .

B, C. Notopodial setae from 5th segment. A lanceolate type occurring in a dorsal position.  $\times 325$ .

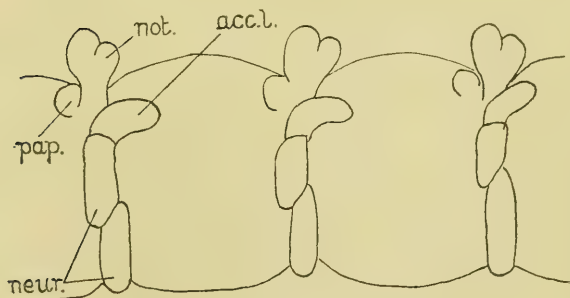
while the figure of *T. costarum* shows little of such a differentiation. I should like, however, to assure myself of the importance of this point (which is strongly emphasised by Gravier) on more and better material and by a comparison with specimens from Naples.

In the 4th segment there is a single greatly enlarged seta (text-fig. 6 A). The point of this is an irregular triangle. The base is slightly curved and quite entire (in *T. bonhourei* it is furnished with a fringe of projecting points). The longer of the outer sides is furnished with very unequal serrations. There is also an auxiliary bundle consisting of a few fine setae, such as is figured for *T. costarum*, while it is expressly stated that it does not exist in *T. bonhourei*. A series of types of notopodial setae is shown in text-fig. 7.

Text-figure 7.

*Telepsavus* sp.Other types of notopodial setæ from anterior region.  $\times 325$ .

Text-figure 8.

*Telepsavus* sp.

Lateral view of posterior region.

*not.*, notopodium; *acc.l.*, accessory lobe of this; *pap.*, papilla of unknown nature; *neur.*, neuropodium.

Behind the anterior region there are between 30 and 40 segments, all of the same type with a bifid notopodium (text-fig. 8). The first three segments are distinctly longer than the rest, and

there is no such development of glandular papillæ on their dorsal surface as is figured in the Neapolitan species (but absent in *T. bonhourei*). The parapodia throughout consist, as is usual, of a bifid notopodium with capillary setæ, a lateral accessory lobe such as occurs in *Phyllochætopterus*, and a double neuropodium consisting of two adjacent uncinigerous ridges. There is, moreover, in all the segments a very distinct, occasionally double, papilla just anterior to the notopodium. This may be the nephridial papilla, but, if so, its position is more dorsal than usual.

The ventral surface of the anterior region is deeply tinged with a brown to purple pigment. In this it apparently resembles *T. costarum*, while in *T. bonhourei* the 7th segment alone is markedly pigmented.

From the points which have been stated here it will be seen that the form certainly differs specifically from *T. bonhourei* and probably also from *T. costarum*.

#### PHYLLOCHÆTOPTERUS Grube.

PHYLLOCHÆTOPTERUS PROLIFICA, sp. n. (Plates IV., V.; Text-fig. 11.)

*Phyllochætopterus* of small size (1–3 cm. in length), with eye-spots. Anterior region usually with 12 setigerous segments; a single enlarged seta in each parapodium of the 4th segment. Median region with a very variable number of segments. In segments of posterior region each notopodium contains a single seta. Tubes creeping, usually containing several individuals and possessing several short branches opening to the exterior.

This species of *Phyllochætopterus* was first collected outside the harbour of Nanaimo. Here, as was proved by frequent dredgings between the Five Finger Rocks on the north and the island of Gabriola to the south, the muddy bottom is covered with a thick growth of hexactinellid sponges (*Bathydorus dawsoni*, *Aphrocallistes whiteavesii*), and associated with these are the thin and delicate tubes which prove to contain *Phyllochætopterus*, sometimes sparsely scattered, sometimes in such thick and tangled masses that the dredge contained little else. Later in the year, a visit to the Marine Biological Station of the University of Washington at Friday Harbour showed that this annelid occurs abundantly in various localities in Puget Sound. It was dredged at many points in the San Juan Archipelago and found associated with very different companions. In the dredgings from deeper water (down to 60 fathoms) masses of large barnacles (*Balanus aquila*) and the tubes of the Polychæt *Sabellaria* also occurred; in shallower waters (up to 5 fathoms) the *Phyllochætopterus* tubes were entwined with red seaweeds. But though the vertical range as seen above is fairly notable, it never occurs above low-tide mark, where it is succeeded by the other members of the family, *Mesochætopterus* and *Telepsavus*.

The fact that though so abundant this Phyllochaetopterid has remained up to the present undescribed is due to the slender nature of the tubes, which easily escape identification as the habitation of an annelid, and to the difficulty of preservation.

In its wide distribution and its habit of forming intertwined masses of tubes, *P. prolifica* resembles *P. socialis* of the Mediterranean, of which Claparède wrote in 1866: "Cette annélide est probablement l'espèce la plus abondante dans le golfe de Naples\*", où ses tubes juxtaposés, grisâtres, papyracés et enchevêtrés les uns dans les autres par leur extrémité postérieure, paraissent former d'immenses prairies. Du moins les pêcheurs apportent-ils à première requisition, sous la nom de *ceppa grande*, des pièces qu'on prendrait pour de grands quartiers de gazon, et qui sont formées presque exclusivement par les tubes de ce Phyllochaetoptère." In *P. pictus*, too, described by Cyril Crossland (2) from Zanzibar in 1903, a similar habit was observed. On the occasion of its discovery the tubes "were found clustered together in considerable numbers on the underside of a large stone at low-water level." But in the remaining species of the genus hitherto described the worms inhabit straight solitary tubes.

As will be seen later, examination of the individuals of *P. prolifica* shows that the size and external characteristics of the species tally fairly well with the description of *P. socialis*. But that there is a deeper physiological connection is indicated by the occurrence in both species of more than one individual in a single tube. The phenomenon of asexual reproduction, which Claparède suggested as the cause of the colonial habit in *P. socialis*, I wish to record here as the outstanding feature of *P. prolifica*.

I will first give Claparède's statement on this point which follows immediately after the passage quoted above:—"L'étude de cette annélide a fait surgir quelques curieux problèmes physiologiques. Les *ceppa grandi* qu'apportent les pêcheurs sont formées exclusivement par des individus d'un même sexe, généralement des mâles, les femelles étant à ce qu'il semble beaucoup plus rares que les mâles. En outre, chaque tube est régulièrement habité par deux ou trois individus, tous adultes et mûrs. Le tube est cependant si étroit que seul l'individu antérieur peut fait sortir ses tentacules par l'ouverture, tandis que les suivants sont emprisonnés derrière lui. Dans de pareilles conditions, on doit supposer tout naturellement que ces derniers ont été engendrés par bourgeonnement postérieur à l'extrémité du premier, et que peut-être même tous les individus d'une même *ceppa* sont nés par gemmation. Toute-fois je n'ai pas réussi à vérifier l'exactitude de cette hypothèse. Je ne suis pas même très-certain des rapports des tubes entre eux. Ces petites habitations cylindriques larges à peine d'un millimètre et longues parfois de 8 à 10 centimètres, sont irrégulièrement contournées dans leur partie postérieure, sondées les unes aux autres, et ne peuvent se séparer sans

\* I understand that *P. socialis* is now considered something of a rarity at Naples.

déchirures. Il m'a semblé quelles s'anastomosaient parfois, cependant j'éprouve quelque hésitation à affirmer ce point. Il y a donc, on le voit, encore bien des questions à vider au sujet de ces vers."

The incompleteness of Claparède's observations leaves us in some uncertainty with regard to *P. socialis*. As I understand the foregoing passage, he was unable to assure himself as to which of the following alternatives was correct. Either;

(1) There are a number of unbranched tubes packed close together, but without connection, each tube containing two or three individuals, but having only a single opening;

Or else (2) these adjacent tubes are in reality connected with one another, and the whole bundle of tubes (*ceppa*) is a single colony, all the worms contained in which have probably been budded off from a single original individual. This is supported by the fact that the worms in a bundle are all of the same sex.

In *P. prolifica*, on the other hand, the relations of the tubes are perfectly clear. Where they come into contact they do not adhere in the complex manner described by Claparède. In the following paragraph I state shortly the conditions which are found in the colonies.

The tubes are comparatively long and sometimes divide into two or more branches of approximately equal length. Most contain more than one worm and some as many as six. The main tube is provided with several short branches which open to the exterior, but the number of openings does not correspond to the number of worms in the tube. The worms can change their position in the tube fairly rapidly and can turn round and pass each other. Those individuals which occupy a favourable position protrude their long tentacles from one of the openings to assist in the collection of food.

It occurred to me on first observing the above facts, while I was still unaware of Claparède's observations on *P. socialis*, that an explanation was probably to be found by supposing some sort of asexual reproduction to occur in the species. The nature of this reproduction was indicated by a discovery made during an early examination of the living material at Departure Bay. I was surprised to find emerging from freshly dredged tubes very short individuals which differed considerably from the normal forms in the constitution of their bodies. One of these only measured 6 mm., which is  $\frac{1}{3}$ — $\frac{1}{4}$  of the normal length. The segments of which it was composed were arranged as follows:—

|                 |       |               |
|-----------------|-------|---------------|
| Anterior region | ..... | 8 segments.   |
| Median          | „     | ..... 2 „     |
| Posterior       | „     | ..... 20-30 „ |

Not only did the anterior region consist of less than the normal number of segments (12), but also there was no segment with a modified seta such as occurs in all adults of the species, and the peristomial tentacles were represented by minute stumps. The number of segments in the median region was exceedingly

small, but the segments themselves both here and in the posterior region were normally developed, while there could not be the slightest doubt but that the anterior region was in process of regeneration.

A second individual found at the same time gave another stage in the phenomenon. It was more nearly the normal size. The regions contained the following numbers of segments:—

|                             |              |
|-----------------------------|--------------|
| Anterior region.....        | 11 segments. |
| Median     "         .....  | 5     "      |
| Posterior   "         ..... | 20-30     "  |

The anterior region thus contained nearly the normal number of segments, but it was shorter than usual and the peristomial tentacles were less than half the usual length. This seemed a second case in which the anterior region was regenerating.

On returning to Cambridge, a detailed examination of a large amount of material preserved in formalin was made. Tube by tube was taken and slit up, and the length and constitution of the three regions noted in all the individuals contained therein. It was quite clearly shown that living constantly though the animals do within the shelter of a tube, regenerating specimens are frequently found. From an examination of these it seems certain that a fragment of *Phyllochætoperus* containing only segments of the median and posterior regions easily regenerates an entire anterior region. The number of cases in which this phenomenon has apparently occurred, and the fact that in their protected situation regeneration after external injury is an unlikely event, leads me to suppose that these animals have the power of autotomy and that it is exercised for the distinct purpose of reproduction.

The tables which follow present the results of the detailed examination of several tubes, each represented by a separate

TABLE I.

|            | Constitution of the three body regions.  |               |                  | Total length of worm. |
|------------|--|---------------|------------------|-----------------------|
|            | A.<br>Anterior.  | B.<br>Median. | C.<br>Posterior. |                       |
| No. 1..... | 12   | 6             | 5                | 1·3 mm.               |
| No. 2..... | 12   | 7             | none             | 1·8 mm.               |
| No. 3 .. { | Small regenerating stump<br>1 mm. long; segments<br>not sufficiently differ-<br>entiated to count. |               | 5                | 32                    |
|            |  |               |                  | ...                   |

table. The figures in the columns A, B, and C indicate throughout the numbers of segments in the regions referred to.

In this tube (Table I.) from Departure Bay Nos. 2 and 3 appear to be complementary, and represent an individual broken in two in the median region. While, however, the median segments of No. 3 have already regenerated a short and undifferentiated region, those of No. 2 have not yet attempted to form a posterior region. The regenerating end of No. 3 is figured in Pl. V. fig. 12, and it will be seen that a number of segments have been marked off by furrows, but that parapodia and setæ have not yet developed. The peristomium is indicated by the rudimentary tentacles. It will be noticed that almost the full number of segments is established at once, and apparently development proceeds simultaneously in each of them.

TABLE II.

|           | A. | Length of A*.             | B. | C.                                      | Total length. |
|-----------|----|---------------------------|----|---|---------------|
| No. 1 ... | 11 | 5.5 mm. ( $\frac{1}{4}$ ) | 10 | 12                                      | 20 mm.        |
| No. 2 ... | 9  | 4 mm. ( $\frac{1}{4}$ )   | 8  | 22                                      | 15 mm.        |
| No. 3 ... | 12 | 2 mm. ( $\frac{1}{6}$ )   | 8  | 40                                      | 17.5 mm.      |
| No. 4 ... | 12 | 4 mm. ( $\frac{1}{3}$ )   | 4  | 28<br>(+ number of very small segments) | 19 mm.        |
| No. 5 ... | 12 | 6.5 mm. ( $\frac{1}{3}$ ) | 14 | 20                                      | 21 mm.        |
| No. 6 ... | 12 | ...                       | 3  | 20                                      | 16 mm.        |

Another tube from Friday Harbour (Table II.) contained six individuals, all of which with one exception were well-developed and complete specimens. It will be seen that while the number of segments is more constant in the anterior region than in the other two, its length varies very considerably and bears no definite relation to the total length of the body. In No. 3 (Plate V. fig. 13) it is extremely short, although it possesses the usual number of segments, which are of normal width and have the full development of setæ. There is, however, no strengthened seta in the fourth segment, and the peristomial tentacles are about half-grown.

In the other individuals the length of this region varies from 4-6.5 mm.

\* The fraction in this column represents the proportion borne by the length of A to the total length.

TABLE III.

|           | A.  | Length of A.                     | B.  | C.                              | Total length. |
|-----------|-----|----------------------------------|-----|---------------------------------|---------------|
| No. 1 ... | 12  | 6 mm. ( $\frac{1}{5}$ )          | 8   | 26                              | 30 mm.        |
| No. 2 ... | ... | ...                              | ... | 13                              | 6 mm.         |
| No. 3 ... | ... | a very small regenerating stump. |     | 22                              | 12 mm.        |
| No. 4 ... | 12  | 5.5 mm. ( $\frac{1}{4}$ )        | 10  | 10                              | 24 mm.        |
| No. 5 ... | 12  | 6 mm. ( $\frac{2}{3}$ )          | 7   | 22<br>+ 15 very small segments. | 27 mm.        |

In this colony (also from Friday Harbour) there are three worms complete anteriorly and two fragments, one of which is commencing regeneration. Of the first-mentioned, however, No. 4 has probably lately suffered the loss of posterior segments, as shown by the small number of those remaining and the moderate total length. No. 5 is interesting from the possession of a tail of very small posterior segments following others of normal size, and these must represent regeneration after autotomy.

From the comparative rarity of regenerated tails in autotomised worms, it is evident that the anterior region is re-formed much more quickly than the posterior. With regard to the median region, there are two facts which seem to show that regeneration of new segments of this type takes place but rarely. These are:

(1) the great variation in the number of segments (from 4 to 14), even in individuals with well-developed anterior and posterior regions, and

(2) the absence of segments of two different sizes in the region. I have, however, examined one animal alive in its tube in which the normal segments of the median region were preceded by a single newly formed segment of similar type, but only about half the size of the others. I cannot say whether the anterior region was fully formed or not. Cases of regeneration of median segments then do exist, if but rarely.

The facts incline me to suggest that asexual generation only occurs successfully when fragmentation takes place in the median region, that regeneration proceeds both on the anterior and posterior surfaces of the plane of rupture, however small a number of segments are left on one side, but that these median segments usually regenerate anterior or posterior segments, and

only segments like themselves when the other two regions have been completed.

Fragments consisting of segments of the posterior region alone are, however, occasionally met with, and in one case (Table III. No. 3) a minute regenerating stump was found. At the same time there is no evidence that complete regeneration occurs from abdominal segments alone.

Another case may be mentioned in which autotomy had occurred in the middle of the anterior region and a number of segments of smaller size were superimposed on the older segments.

Plate V. illustrates two well-marked regeneration stages of the anterior region from individuals mentioned above, and they should be compared with the individual of normal development shown on the same plate (fig. 14).

#### REGENERATION IN *Chaetopterus*.

Since the above was written, I have read the observations of Gravier on autotomy and regeneration in *Chaetopterus variopedatus*. When an individual is seized by the anterior part of the body, or when it is strongly irritated, rupture takes place between the first and second segments of the median region—this being the place of least resistance. The anterior fragment can reproduce all the rest: the posterior has not always been regarded as capable of regeneration. But Gravier (6) describes and figures a posterior fragment, collected at Saint Vaast-la-Hogue, which carries a regenerated anterior region fully differentiated but quite minute. Gravier's drawing (*l. c.* fig. 2, p. 147) resembles almost exactly those I have given for *P. prolifica*. The whole anterior region hardly equals in length a single original segment, but it possesses a buccal funnel and peristomial tentacles, and the lateral border is marked out into segments, 12 conical seta-bearing notopodia being present on each side. Only in the 4th segment the special setæ are not indicated, and the peristomial tentacles are unequally developed. There are some irregularities, also, in the notopodia, but, generally speaking, they are of nearly equal development. Only the last segment is markedly smaller than the rest, which thus appear to be marked off nearly simultaneously. The total number of segments is 12, while the normal number is only 9. Individuals with 12 segments are very exceptional, and it is curious to find that in regeneration the maximum number of segments should be formed.

The first segment of the median region is present, but in a very rudimentary condition. Noto- and neuropodia are visible, but it has obviously been formed after the segments of the anterior region.

If we summarise the phenomenon so far as it is known in *Chaetopterus*, it may be said (1) that autotomy occurs sometimes

as the result of an unexpected stimulus\*; (2) that, following autotomy, regeneration will take place from the posterior fragment, the median region thus giving rise to the whole of the anterior region, and after that replacing the missing median segment.

There is thus a clear resemblance to the manner of regeneration in *Phyllochaetopterus* and also a clear minor distinction, the presence of a definite breaking-point in *Chaetopterus* and its absence in *Phyllochaetopterus*. Autotomy and a complete type of regeneration are thus to some extent characteristic of the family Chaetopteridae. In *Phyllochaetopterus prolifica*, however, the occasions on which autotomy takes place are so frequent and regular as to subserve a definite method of asexual reproduction. But the nature of the stimuli which cause autotomy, and the question whether the phenomenon is in any sense under the control of the animal itself, can hardly be approached as yet.

Some advantage may, I think, be gained by comparing the cases of regeneration studied in other Polychaeta with a differentiation of regions. Ivanow (8) and other authors have made a very thorough examination of these phenomena in the case of the Sabellid *Spirographis spallanzanii*. Here there are three regions: the *anterior thoracic* with the prostomium, bearing the enormously developed tentacles, and the first three setigerous segments; the *posterior thoracic*, consisting of eight or nine following segments; and the *abdominal*, with an indefinite number of segments. Only such fragments regenerate as consist of abdominal segments or of abdominal and thoracic segments. Those containing thoracic segments only always disintegrate. In regenerating fragments, the hinder end always produces abdominal segments, and the anterior end regenerates the prostomium and the three anterior thoracic segments. The posterior thorax develops later by the metamorphosis of the most anterior abdominal segments, a striking change taking place in the characters of the parapodia. The dorsal uncini are replaced by capillary setae, while in the neuropodium the capillary setae are replaced by uncini.

A similar phenomenon has been described by Watson (12) in *Potamilla reniformis*, another Sabellid. Here, in the regeneration of the anterior region from abdominal fragments, the prostomium and *one* new setigerous thoracic segment only are formed as a new growth: all the rest of the thoracic segments are formed from abdominal segments in which a modification of the parapodia like that described above occurs. It is curious that two regions, differing from each other so little in morphological characters as do the anterior and posterior thoracic regions of *Spirographis*, should have such a dissimilar method of re-formation.

Though my observations on regeneration in *Phyllochaetopterus*

\* In 1913, at Plymouth, I noticed that of a tubful of *Chaetopterus* which had been brought in, after being kept on board a trawler for 20 hours or so, nearly all had autotomised, as a result of the unhealthy conditions, rupture taking place between the first and second segments of the median region.

are incomplete, it seems probable that the phenomenon here runs a very different course. The three regions of the Chætopterid have no probable connection with those of the Sabellid, nor is there any reason that they should behave in a physiologically similar manner. In *Phyllochætopterus* it seems fairly certain, as I have pointed out above, that regeneration takes place most often from fragments containing median as well as posterior (abdominal) segments, and in all cases the full number of segments in the anterior region is budded off. But, while in both Chætopterids and Sabellids the anterior region is restored by regeneration, in the former family the median region is not completely re-formed as is the case in the latter. The number of segments in the median region is so variable in number that for this and other reasons I am inclined to suppose that regeneration does not take place here, or only very slowly. There is certainly not the slightest evidence, in any regenerating individuals which I have examined, of a transformation of the posterior (abdominal) segments into median segments, such as characterises the Sabellids.

#### THE POSSIBILITY OF ASEXUAL GENERATION IN *P. pictus*.

The case of *Phyllochætopterus pictus* described by Crossland has already been mentioned. It will be interesting here to quote some figures which Crossland gives to show the variability in the numbers of segments in the anterior (A) and median (B) regions. Eight individuals were examined. They are indicated by the Roman numerals running across the page:—

|       | I. | II. | III. | IV. | V. | VI. | VII. | VIII. |
|-------|----|-----|------|-----|----|-----|------|-------|
| A ... | 15 | 16  | ...  | 13  | 15 | 12  | 15   | 13    |
| B ... | 7  | 9   | 5    | 7   | 5  | 3   | 8    | ...   |

Here, too, it will be seen that the median region is much more variable than the anterior, the numbers ranging from 3–9 for a very small sample of individuals. In view of this and the fact that the annelid inhabits clusters of tubes, the relations of which are difficult to make out, I think it is possible that asexual generation occurs here too.

#### MISCELLANEOUS OBSERVATIONS ON THE HABITS OF *Phyllochætopterus prolifica*.

Owing to the transparency of the tube, in the younger colonies at least, it is possible to see something of the movements of the worm within. It shifts its position in the tube by the alternate relaxation and contraction of the body; when contraction occurs, the setæ of that part of the body affected are braced against the sides of the tube. The setæ of the abdomen can be definitely

used as organs of progression, pushing the animal along. The worms can thus move with some rapidity, and they can also turn within the tube and even pass each other. When at rest they generally lie with the long tentacles projecting from an aperture evidently questing for food. All the inhabitants of the tube may not be able to obtain such advantageous situations, but from their activity within the tube it is evident that a frequent interchange of position does take place. The worms do not all lie the same way, so it is difficult to see how a constant and sufficient circulation of water can be maintained through the whole tube. Probably at times the animal is entirely quiescent and the respiratory current interrupted. In all the animals I observed, the action of the cilia in the dorsal groove and of the notopodia of the median region is responsible for a current running posteriorly, which supplies not only oxygen but also food, as in the other *Chaetopterids*. This action is sometimes vigorously supplemented by the undulatory movements of the abdomen. This energetic action—a phenomenon often observed, too, in *Chaetopterus*—is possibly necessary for removing objectionable particles from the neighbourhood of the body. In *P. anglica* and to a less degree in *P. prolifica*, it may be seen, however, that the circulation of water is not always thorough, for large sections of the tube behind worms are blocked by faecal masses, and this may eventually necessitate the abandonment of the old parts and extension of the colony.

I have not observed any individuals bearing genital products, but this is probably due to insufficient examination, and I should not like to suggest that asexual generation has supplanted the sexual method. Isolated individuals (like those of *Chaetopterus*) are not able to manufacture fresh tubes in spite of copious secretion of mucus, and new colonies must be formed in the first place by a single individual developed from a fertilised egg, though this, by fragmentation, gives rise to all the inhabitants of the colony. Claparède made the interesting observation that, in *P. socialis*, all the worms in a bundle of tubes developed genital products of the same sex, indicating that they were all derived from a single sexually produced embryo.

#### SOME POINTS IN THE MORPHOLOGY OF THE CHÆTOPTERIDÆ.

*Variation in Form of the Notopodia.*—Behind the anterior region of the body both notopodium and neuropodium are present in the parapodium. In nearly all cases the neuropodium is stable and retains its character as a double uncinigerous ridge. In *Mesochaetopterus*, where the first neuropodium of the median region is single, there is a slight modification, and in *Chaetopterus* the neuropodia of opposite sides in the median region are fused to form a sucker.

The notopodium, on the other hand, is very variable, and it

may be of some service to arrange the different types in a tabular form:—

|   |  |  |
|---|--|--|
| A single lobe without setæ .....                            |  | <i>Ranzania</i> , 16th and all succeeding segments.  |
| A single conical lobe with setæ.                            | { A single seta .....  | Most species of <i>Phyllochætopterus</i> in the posterior region.  |
|   | { Several setæ .....   | <i>Chætopterus</i> and <i>Phyllochætopterus aciculigerus</i> , <i>claparedei</i> in the posterior region.<br><i>Ranzania</i> , 13th and 14th segments. |
| A bilobed foliaceous structure with several capillary setæ. | { <i>Phyllochætopterus</i> , in the median region.             | { A conical or aliform grooved structure (with several capillary setæ).  |
|   | { <i>Telepsarus</i> , all segments behind the anterior region. |  |
|   |  | <i>Chætopterus</i> , 1st segment of median region.   |
|   |  | <i>Mesochætopterus</i> , median region.  |
|   |  | The two notopodia of the segment fused to form a fan-like structure.   |
|   |  | <i>Chætopterus</i> , segments 3-5 of median region.  |

The structural types can thus be arranged in a neat series, and there is some evidence to show the direction in which evolution has taken place. Both the conical and the foliaceous types are adapted, the one for progression in the tube, the other for the respiratory function. But since the median region has been clearly developed from the posterior, and the conical type of posterior notopodium is far more widespread than the foliaceous type (*Telepsarus* alone), it seems reasonable to regard the conical notopodium as the more primitive. In this case, *Telepsarus* is a specialised form, in which all the posterior segments have developed foliaceous notopodia and the original type has been lost. But *Ranzania*, though the parapodia are unilobed throughout the body, is not to be regarded as the primitive form from which the Chætopterids diverged. The absence of setæ from most of the posterior notopodia and of long tentacles may surely be regarded as secondary. The 13th and 14th segments are so distinct from the rest as to almost merit inclusion in a separate median region.

#### *The Head in the Chætopteridae.*

In the structure of the head there is also a certain amount of variation in the family. The *prostomium* is in most cases provided with eyes, but it is small in all forms and almost surrounded by the *peristomium*, which forms a collar. In *Chætopterus* and *Mesochætopterus* this collar is so complete as almost to hide the prostomium, while in *Phyllochætopterus* it is incomplete dorsally and shallow, allowing the prostomium to be seen easily. The peristomium gives rise to a pair of tentacles which vary greatly in length, and in *Phyllochætopterus* there is also a second pair of

structures which are generally stated to be tentacles. They are very small flat organs, lying on each side of the prostomium, and generally covering the eyes. Claparède showed, in the case of *P. socialis*, that they contained two or three thin capillary setæ. This circumstance is easily verified in such species as I have examined, and it leads me to suggest that we are in error in regarding these structures as tentacles. They are much more probably the reduced and modified notopodia of the peristomial segment itself.

It may be of some advantage to dwell on this point at greater length. In Annelids the *peristomium* is the segment behind the prostomium, and it can be generally recognised and homologised throughout the group. This fact is, however, due more to its position than to any morphological characters which distinguish it from those succeeding, and it is generally recognised as the most anterior of the trunk-segments, which has been considerably modified in connection with the mouth. With regard to its identity with the other segments of the trunk, Goodrich says:—"Careful modern researches (Vejdovsky, Wilson, etc.) have shown that in Oligochaetes the peristomium exhibits the essential characters of a true segment. It develops as a region surrounding the mouth, in which are formed a pair of mesoblastic somites which become hollowed out to form the cœlom; a ganglionic thickening is produced ventrally, which soon fuses with that of the succeeding segment; a nephridium (head kidney) is developed. In the Polychætes—in some cases, at all events,—it has been shown that a pair of somites are formed in the peristomium, become hollowed out, and even give rise to peritoneal funnels. Nephridia are almost invariably developed in this segment. In Polychætes, moreover, a pair of lateral appendages are often developed, though they generally become highly modified. In fact, it becomes evident, when we examine the development and the adult structure of the peristomium in the various groups of the Annelids, that it is really a metamere strictly comparable to the posterior segments, even when much modified owing to its position at the anterior end of the animal."

In the Syllids, the Polynoids, and other groups, the peristomium consists of a segment which bears on each side a dorsal and a ventral cirrus. That these are the remains of a typical parapodium, in which the notopodium and neuropodium with their setæ have disappeared, is shown by a number of cases amongst the Polynoids, which could probably be duplicated in other families, where the first segment carries not only cirri but also setæ. In *Polynoë extenuata*, described by Claparède, the peristomium shows an aciculum and a couple of setæ. In *Pontogenia*, *Sthenelais*, *Sigalion*, and in *Palmyra* amongst the Palmyridæ, the peristomium possesses a notopodium with several setæ, and only differs from the succeeding segments in the absence of neuropodial setæ.

These cases show that the peristomium may be an almost

unmodified trunk-segment. On the other hand, it often occurs that trunk-segments fuse with the peristomium and then lose their parapodia, with the exception of the dorsal and ventral cirri. So that the same process which has affected the peristomium may modify the succeeding segments in a similar way.

The object of this digression is to show that the retention of a parapodium in the peristomium of *Phyllochaetopterus* is by no means without parallel in other families of Polychaets. The constancy of the phenomenon makes it of generic value, and suggests that possibly the rudimentary notopodium has undergone a change of function which we cannot yet appreciate.

DESCRIPTION OF A NEW SPECIES, *P. anglica*, FROM BRITISH WATERS,  
AND A COMPARISON OF THOSE SPECIES OF THE GENUS WHICH  
FORM TRUE COLONIES.

PHYLLOCHAETOPTERUS ANGLICA. (Pl. VI.; Text-figs. 9, 10, 12.)

*Phyllochaetopterus of moderate size (2-12 cm. in length), with eye-spots. Anterior region with a variable number of segments (13-16); a single enlarged seta in each parapodium of the 4th segment. Median region also with a variable number of segments (11-25). Tubes creeping; often several run parallel to each other, with short lateral connections. More than one individual in the same system of tubes.*

*Locality.* English Channel.

I obtained this species in March of the present year (1913), while working at the laboratory of the Marine Biological Association at Plymouth. Tubs of *Chaetopterus*-tubes were brought in from trawlers, apparently obtained from an area a little south of the Eddystone. Attached to the *Chaetopterus*-tubes were numbers of other very slender tubes, often arranged in parallel bundles. Sometimes they were embedded in the substance of the larger tube, at other times they were entirely surrounded by large colonies of *Alcyonium*, so that it seems that the communities of *Phyllochaetopterus anglica* are of comparatively long standing.

In the character of its colonies this species seems to be intermediate between *P. socialis* and *P. prolifica*, and it will be profitable to make a definite comparison:—

(1) In *P. prolifica* (Pl. IV.) the colony is usually contained in a single, long, stolon-like tube (sometimes bifurcating) with a number of very short branches communicating with the exterior, and consists of a comparatively large number of small individuals which reproduce asexually with rapidity (at least in the summer).

(2) In *P. socialis* the colony seems to occupy a large number of parallel and adherent tubes, the communication between which can only be made out with great difficulty. In each mass of tubes the individuals are, however, of the same sex. A single tube contains two or three individuals.

(3) In *P. anglica* (Pl. VI. figs. 15, 16) the colony is likewise contained in a number of tubes, which tend to run parallel, but are not, as a rule, adherent. The open nature of the colony leaves

no but doubt that the tubes are connected. Usually each constituent tube contains a single individual longer than those of *P. prolifica*. Small subsidiary apertures may be placed at the end of branchlets of the main tube, as in *P. prolifica*.

These distinctions which I have attempted to draw may, on further examination of the genus, prove to be insufficiently grounded. I feel quite certain, however, that *P. prolifica* in the N.E. Pacific does not usually form the dense colonies characteristic of *P. socialis*, nor do connected tubes run parallel as in *P. anglica*.

It is possible, too, that these three species differ in the extent to which asexual reproduction is developed in each. In particular, it may be mentioned that *P. prolifica* is the only species in which asexual reproduction was found to be proceeding at the moment of discovery.\* In *P. anglica* I was not successful in finding any example which showed signs of recent regeneration. It is probable that this phenomenon takes place later in the year than the time when my specimens were collected, but I incline to believe that autotomy and regeneration are never so frequent as in *P. prolifica*, a circumstance which accounts for the smaller number of individuals contained in much longer tubes.

In the morphological characters of the animals themselves, I must confess to a considerable difficulty in distinguishing between these three species. Mr. Crossland has pointed out that some species of *Phyllochaetopterus* are easily recognised by definite characters, like the number of modified setae in the notopodium of the fourth setigerous segment, the presence or absence of eye-spots, and the number of setae in the notopodium of the posterior region (C), as well as the character of the tubes. In all four species, which have developed asexual reproduction, eye-spots are present, a single strengthened seta is usually found in the notopodium of the fourth segment and a single seta in each notopodium of region C, while the tubes they inhabit are creeping and branched. It seems to me that there is sufficient difference between the forms here described to preserve them as distinct species, though they must, from their morphological characters, as well as from their manner of life and reproduction, be classed as very nearly related. There are, moreover, differences in the size, the number of segments in the several regions of the body, and in the shape of the prostomium and peristomium which help to supplement the biological peculiarities which I have indicated above.

*Comparison of the external Morphology of those Species of  
Phyllochaetopterus which form True Colonies.*

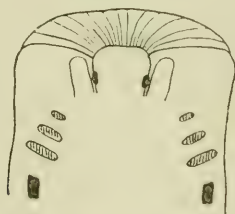
(1) *The Prostomium and Peristomium.*—In *P. anglica*, the prostomium (text-fig. 9) is rather broad, though small, and its borders are marked by a line of dark pigment. The eyes are placed on the extreme side of the head, and are overlapped and

\* This was in the summer (May-July).

hidden by the peristomial appendages, which are here small and slender objects. The peristomium forms a well-developed funnel. In *P. prolifica*, on the other hand, though I have examined a large number of individuals, I have experienced considerable difficulty in making out the relations of the pro- and peristomium. I think it is possible to say that the prostomium is smaller, and less definite than in *P. anglica*, and that the peristomial appendages are quite minute, and do not cover the eyes. The peristomial funnel is complete.

I have been able to examine two of the species described by Mr. Crossland, and preserved in the Museum of Zoology at Cambridge, to test the variation which occurs in the different species of *Phyllochætopterus*. In *P. elioti* from Zanzibar the peristomial appendages are comparatively large and definite structures, though they do not cover the eyes, the prostomium is much better developed than in *P. anglica* and *P. prolifica*, but the peristomial funnel completes little more than a semicircle (Crossland, 2, pl. xiv. fig. 1).

Text-figure 9.



*Phyllochætopterus anglica*.

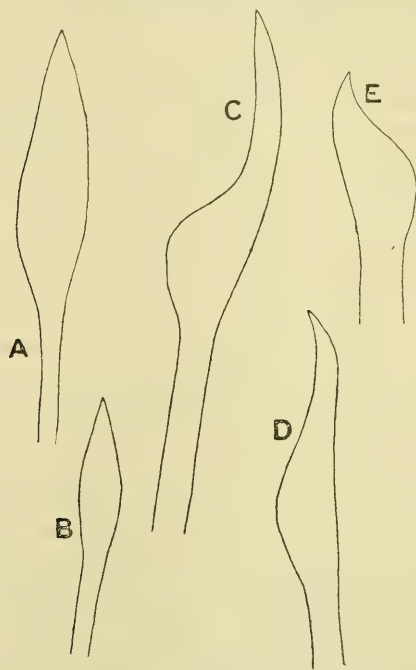
Dorsal view of head and anterior segments.

In *P. pictus*, also from the neighbourhood of Zanzibar, the prostomium is rather large and fleshy, and the peristomium does not form a funnel but a conical elevation, divided behind by a median groove; the mouth is a small slit-like aperture. In another species *P. aciculigerus* described by Crossland, the peristomium is very much reduced, forming a cone with a rounded mouth. The prostomium is small, but definite.

From the small series of species here examined, I have ventured to draw some conclusions. The prostomium is always a very definite organ, except in a species like *P. prolifica*, where the peristomial collar is quite complete. The peristomium, however, varies a good deal. In *P. pictus* and *aciculigerus* it is small and rudimentary, while in other forms it is developed into a funnel—markedly incomplete, for instance, in *P. elioti*, less so in *P. anglica*. With the completion of the peristomial funnel in *Mesochætopterus taylora* and *Chætopterus* we have the suppression of the prostomium and the complete disappearance of the peristomial appendages. I think that the conical peristomium is primitive and that the formation of the peristomial funnel is a direct adaptation to microphagous habits.

(2) *The Setæ*.—A good deal of time has been spent in endeavouring to fix the value of the notopodial setæ of the anterior region as a basis of classification. It must, however, be stated that the results of this enquiry are entirely negative. The variation in the shape of the setæ is almost endless, and seems to occur indiscriminately in species and individual. The dorsalmost setæ in each parapodium are nearly always lanceolate and symmetrical. Individual variations occur even here in the

Text-figure 10.

*Phyllochaetopterus anglica*.

Series of notopodial setæ from anterior region.

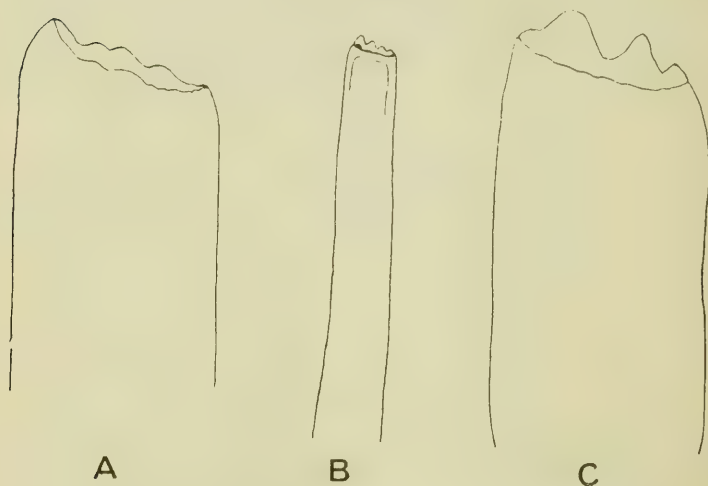
length and thickness of the head, and substantial modification in the more ventral setæ. The following rough classification of types of modification may be given as indicating the range of variation :—

- I. Shortening of the head, which remains symmetrical (text-fig. 10, A, B).
- II. An increasing asymmetry of the head.
  - (a) The head remains long and is drawn out into a long asymmetrical tip (text-fig. 10, C, D).
  - (b) The head is much shortened, with a short tip and a broad edge (text-fig. 10, E).

Minor variations are found, according to whether the sides of the head are curved or straight, to the degree of attenuation and curvature of the tip.

In none of the species which have been described hitherto has a full examination of the notopodial setæ been made. Such figures and notes as are given are of little value, then, in fixing the species; but they show, I think, that the same variations which occur in *P. prolifica* and *anglica* occur in all. I have been able to compare these with the actual specimens of *P. claparedei*, *pictus*, and *elioti* described by Crossland, and this examination supports my conclusion that the notopodial setæ are too variable to base specific characters upon.

Text-figure 11.



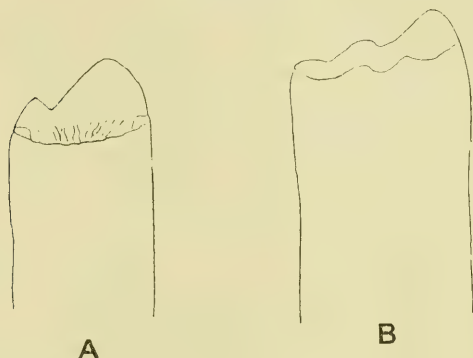
*Phyllochaetopterus prolifica*. Enlarged setæ from 4th segment.

The specially modified setæ in the fourth segment are always figured in descriptions of species, and their configuration is sometimes considered to be of diagnostic value. There is, without doubt, a recognisable type for each genus of the Chaetopterids, but the modifications of this are so many, varying even in the same individual, that I find it impossible to regard the shape of the seta as in any way a specific feature. In all species of *Phyllochaetopterus*, the seta appears to end in a blunt elliptical crown. One or both of the sides of this are raised into a cusped ridge, one ridge being generally higher than the other. The number of cusps is highly variable, and so is their development. Thus in *P. prolifica* (text-fig. 11, A, B) there are on the highest side 3, 4, or 5 cusps, and generally the cusps have a fairly equal development. In some cases, however, like text-fig. 11, C, one or

more of the cusps are of greatly increased size. The lower side of the crown is usually smooth or slightly crenulated.

In *P. anglica* the setæ are often very similar to those of *P. prolifica*. Two setæ are here figured to show the extent of the variation in number and size of cusps. In one of them (text-fig. 12, A) there are only two cusps, one of which is very large. In the other (text-fig. 12, B) the appearance of a cusped lower border will be noticed.

Text-figure 12.



*Phyllochaetopterus anglica*.

Enlarged setæ from 4th segment of two individuals.

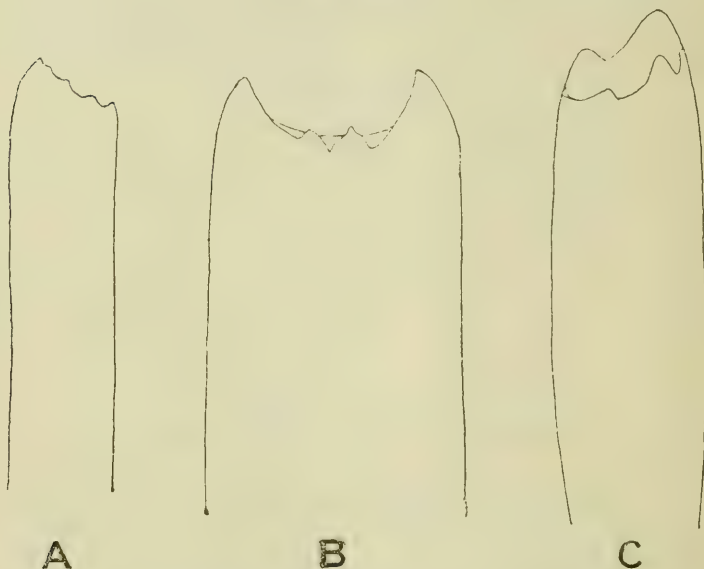
The figure which Crossland has given of *P. pictus* shows an enlarged seta of a type different from any which I have described for *P. prolifica* and *anglica*. In text-fig. 13, C, however, I have drawn another seta from the 4th parapodium of a *P. pictus* collected by Crossland, and I think, it will be seen to be easily derived from the seta shown in text-fig. 12, A (*P. anglica*). The cusps on the lower border are better developed in the first, but otherwise the two are strongly similar. The bulging shaft of the seta mentioned by Crossland is shown also in my mounted specimen, but I have observed similar phenomena in *P. prolifica*.

*P. elioti* is another species which from the published description appears to have a very definite type of strengthened seta. I mounted two or three setæ from Crossland's specimen, and one of these (text-fig. 13, B) agreed fairly well with his figure. On the upper side the two external cusps are greatly enlarged, contrasting with the two small intermediate cusps (not seen at all in Crossland's figure). But another seta (text-fig. 13, A) showed an oblique crown with small equal cusps, like the usual type of *P. prolifica* etc.

It is very probable that the average seta of a species is different

from that of another species, but the point I wish to emphasise is that the setæ of the fourth parapodium vary greatly, and a statement as to their character can only be made after examination of a large series of individuals. It has been shown in the preceding part of this section that the other setæ of the anterior region are always variable, and it would have been rather surprising if those modified setæ which are found in the fourth parapodium had been found to belong to types fixed for each species.

Text-figure 13.

A, B. *Phyllochætopterus elioti*. C. *P. pictus*.

Enlarged setæ from 4th segment.

#### SOME REMARKS ON THE GENERA *Spiochætopterus* AND *Phyllochætopterus*.

Until 1856 *Chætopterus* was the only member of the family known, but in that year Michael Sars (10 a) described the genus *Spiochætopterus* to include a species (*S. typica*) from Norwegian waters, which differed from *Chætopterus* in possessing long peristomial tentacles. In 1863, Grube (7) instituted a third genus, *Phyllochætopterus*, for a worm from the Adriatic. But the two forms are undoubtedly similar, and de Quatrefages, in his 'Histoire des Annélés,' goes so far as to include Grube's polychæt, *P. gracilis*, in the earlier genus *Spiochætopterus*.

*Spiochætopterus typica* was described as living in a jointed transparent tube. It has long peristomial tentacles, but a pair of

peristomial appendages was not observed. There are three well-differentiated regions, the median of which contains two segments with bifid foliaceous notopodia, exactly like those described in all species of *Phyllochaetopterus*. There is only one strongly modified seta in the 4th segment. In the posterior region there is a bundle of fine setæ in the notopodium, but the neuropodium is stated to be without uncini.

*Phyllochaetopterus gracilis*, as originally described by Grube, possesses a pair of short peristomial tentacles. It is possible that in the cases examined the greater part had been broken off, but Grube thinks this was unlikely. Or they may really be very long peristomial appendages, the tentacles being entirely lost. The observations are quite inadequate on this important point.

The 4th segment of the anterior region appears to have more than one strengthened seta on each side, though the number is not actually given. There are two segments here also in the median region, and they are similar in form to those of *Spiochaetopterus*. The posterior region contains segments, the notopodia of which each contains more than one seta; but Grube expresses himself as uncertain whether the neuropodium contains uncini or not.

Neither of these forms has ever been rediscovered so far as I know, and so these descriptions remain still inadequate and uncorrected. But as they stand, I share the opinion of de Quatrefages concerning them, that no sufficient cause is shown for placing the Adriatic form in a separate genus. The differences of the tentacles might be explained as errors of description, and the variation of number of strengthened setæ in the 4th segment is unimportant. The presence or absence of uncini in the neuropodium of the posterior segments is a moot point in both, but it is probably their extremely small size which enabled them to escape detection.

The next question which arises is whether these two forms are similar to those better-known species which are grouped to-day under the genus *Phyllochaetopterus*. For that genus is characterised by the possession of a pair of peristomial appendages, as well as the long tentacles, and they may possibly have been overlooked by Sars and Grube in their respective discoveries. The numbers of enlarged setæ in the 4th segment and in the notopodium of the posterior segments and that of the segments in the median region are not definite generic characters. The structure of the segments of the median region of these two forms is identical with the type usually associated with *Phyllochaetopterus*. It is however, I think, a matter of some importance that these two early forms should be rediscovered and their position more accurately defined. For the present, the generic name *Phyllochaetopterus* must certainly be retained, and I trust it will not be necessary to go back to the older genus *Spiochaetopterus*. But in the table of the Chaetopterids which is given by Crossland he includes *Spiochaetopterus* as distinct from *Phyllochaetopterus* through

its single pair of tentacles. I should like to point out that both genera were originally described as possessing only a single pair of peristomial processes, and that we are not in a position to correct the description of the type-species.

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## EXPLANATION OF THE PLATES.

## Lettering.

- a.s.* Proximal and *p.s.* distal half of posterior segments.  
*cil.gr.* Ciliated groove and *enl.* enlargements of the same to form accessory feeding organs.  
*d.* Dorsal lengthened setae of notopodium.  
*fr.* The frilled borders of the median region.  
*gl.* Glandular epithelium of dorsal surface.  
*lab.* The two ventral lips of the mouth.  
*neur.* Neuropodium.  
*neur.*<sup>1</sup> The undivided neuropodium of the first segment of the median region.  
*neur.*<sup>2</sup>, *neur.*<sup>3</sup> The double neuropodia of the second and third regions.  
*not.* Notopodium.  
*not.*<sup>1</sup>, *not.*<sup>2</sup>, *not.*<sup>3</sup> Notopodia of segments in median region.  
*per.* Peristomial collar.  
*pl.* Ventral plastron of anterior region.  
*pro.* Prostomium.  
*st.t.* Stumps of peristomial tentacle.  
*t.* Peristomial tentacle.  
*w.* Prolongation of the ventral plastron into median region.

## PLATE I.

*Mesochætopterus taylori*, sp. n. Departure Bay, B.C.

- Fig. 1. Dorsal view, comprising the anterior and median regions with the first segments of the posterior region.  
 2. Lateral view of same to show dorsal approximation of the borders (*fr.*) of the median segments, etc.  
 3. View of head from above to show the prostomium completely surrounded by the peristomium, and the slit-like mouth bordered by two ventral lips.

(All three figures are drawn about twice the natural size.)

## PLATE II.

*Mesochætopterus minuta*, sp. n. Cape Verde Is.

- Fig. 4. Dorsal view showing the well-developed prostomium, continuous ciliated groove, absence of frilled borders to median region, etc.  $\times 20$ .

## PLATE III.

*Mesochætopterus*.

- Fig. 5. Ventral view of *M. taylori*, to show end of anterior and beginning of median region.  $\times 3$ .  
 6. Lateral view of posterior region in *M. taylori*.  $\times 3$ .  
 7. Lateral view of end of median and beginning of posterior regions in *M. minuta*.  $\times 10$ .  
 8. Hinder segments of posterior region in *M. minuta*.  $\times 10$ .  
 9. Anterior view of a parapodium in the anterior region of *M. taylori*.

## PLATE IV.

*Phyllochætopterus prolifica*, sp. n.

- Fig. 10. A colony containing three adult worms, two of which (A, B) have just separated off portions (A', B') of the posterior region. The rounded original end of the tube is seen at D.

Departure Bay, British Columbia. Natural size.

11. A colony containing at least three adult worms. This shows two important lateral branches and a large number of short branches bearing apertures. That part of the system represented with close shading is the older, the tube-walls being opaque, and that with distinct annulations is newer, the transparent walls showing the worms within. (Two of these worms which almost touch each other, lie in opposite directions.)

San Juan Archipelago, Washington. Natural size.

(In both figures, the anterior and median regions of the worm are shown dotted, the posterior region very dark. The tentacles are omitted.)

## PLATE V.

*Phyllochætoperus prolifica.*

A series of three individuals showing the stages in the regeneration of the anterior region by a posterior fragment containing segments of the median and posterior regions.

- Fig. 12. Beginning of regeneration: anterior region represented by a tiny stump. Segmentation is indicated by the superficial folds, and the peristomial tentacles are seen as two apical outgrowths.
13. Anterior region is almost complete, but still very small: peristomial tentacles short and fourth segment without enlarged setæ.
14. Adult worm with fully formed anterior region. Tentacles completely developed. The whole of the posterior region is not shown.

## PLATE VI.

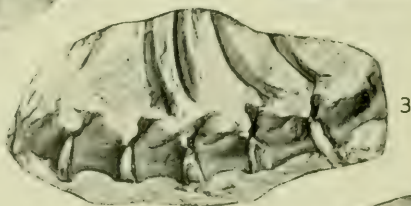
*Phyllochætoperus anglica*, sp. n.

Fig. 15. A colony containing two fully developed worms. It consists of two parallel tubes with short connection. One tube shows the rounded original end. Natural size.

16. A colony consisting of several parallel connected tubes, in part adherent to each other. Only one worm was found inhabiting it. Natural size.

(In both figures, the anterior and median regions of the worm are shown dotted, the posterior region black. The tentacles are shown. The tubes where they are transparent are shown unshaded, where opaque darkly shaded.)

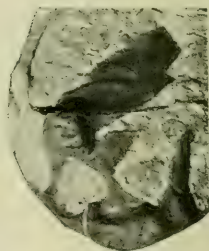




6



5



Bale & Danielsson, L<sup>td</sup> imp.

BROOMIA PERPLEXA.

52. *Broomia perplexa*, gen. et sp. n., a Fossil Reptile from South Africa. By D. M. S. WATSON, M.Sc., F.Z.S., Lecturer on Vertebrate Palæontology in University College, London.

[Received June 3, 1914: Read November 24, 1914.]

(Plate VI.\* and Text-figures 1-5.)

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Whilst collecting on the farm Hottentots Rivier, Field Cornetcy Gouph No. 3, District Beaufort West, Cape Province, from the *Pariasaurus* zone, I was given a lump of the ordinary quartzitic sandstone of that horizon showing an extremely sharp impression of a small lizard-like reptile. By careful development I exposed a perfectly preserved carpus and tarsus with the actual bone well preserved, and the specimen now allows of a very complete account of the animal's structure.

*Skull*.—The skull is represented only by an exquisitely sharp impression of the buccal surface of the palate, squeezes from which show its structure with perfect clearness.

The basioccipital is not definitely visible, but it may be represented by a rather faint impression behind the basisphenoid; it is, however, equally probable that this represents the atlas.

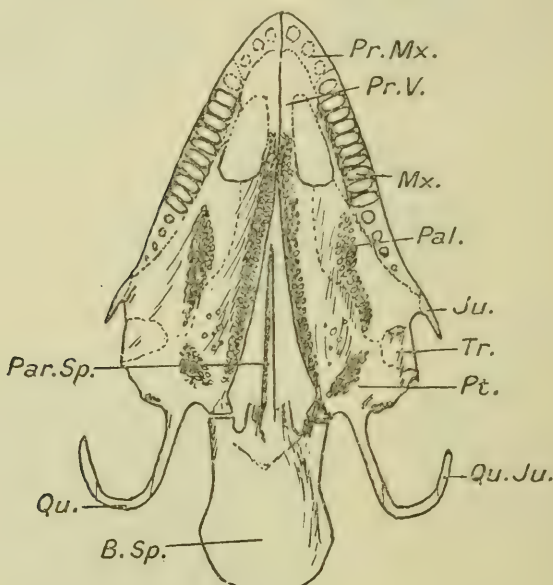
The basisphenoid is very broad, the lower surface is shallowly concave, the lateral borders being raised into low, sharp-edged ridges which slightly separate posteriorly and end in ill-marked tubera. Anteriorly the bone bears two well-marked basiptyergoid processes which, so far from projecting downwards, lie above the general level of the lower surface of the bone; they are directed forwards, and their flat articulating surfaces are nearly at right angles to the length of the skull. Between these processes the parasphenoid projects forward as a very narrow rostrum of considerable length; where it joins the basisphenoid it separates distinct grooves on each side of the middle line which lead from the palate into the skull. There is some evidence that the parasphenoid terminated behind in a diamond-shaped expansion on the lower surface of the basisphenoid.

There are no carotid foramina.

\* For explanation of the Plate see p. 1010.

The pterygoid articulates by a pendunculate facet with the basiptyergoid process; behind this the posterior ramus runs back to the quadrate. It is shown in the specimen as a very narrow strip, but in front there are appearances which suggest that the part visible is really only a narrow rib on the lower surface of a much broader bone, as in *Captorhinus*. In front the pterygoid is not very clearly distinguishable from the palatine and ecto-ptyergoid. It bears three raised ridges, each covered with a granulation of very small, closely-set teeth; the posterior ridge is

Text-figure 1.

*Broomia perplexa*. Restoration of palate.  $\times 2$ .

*B.Sp.*, Basisphenoid; *Ju.*, Jugal; *Mx.*, Maxilla; *Pal.*, Palatine; *Par.Sp.*, Parasphenoid; *Pr.Mx.*, Premaxilla; *Pr.V.*, Prevomer; *Pt.*, Pterygoid; *Qu.*, Quadrate; *Qu.Ju.*, Quadratojugal; *Tr.*, Transverse.

short, directed nearly laterally, and has only a single series of teeth; the second ridge is rather longer, directed forward, and bears two irregular rows of denticles; the third ridge forms the inner margin of the bone and runs forward as far as the specimen allows it to be seen; this ridge is covered with a large number of irregular rows of teeth, so that it forms a closely-set granular area. The surface of the bone between the dentigerous ridges is depressed and between the two anterior ridges has a few small scattered teeth. There is a distinct process applied to the inner

side of the lower jaw, not much depressed, and apparently formed partly by the ectopterygoid, which bears no teeth. In this region there are two small depressions which may be foramina.

A very remarkable feature is the very large size of the interpterygoid vacuity; it is probable that the pterygoids do not meet.

The palatine is a bone which bears a single dentigerous ridge directly continuing the middle one on the pterygoid; where the two bones meet there is a small gap with no teeth; the anterior end of the palatine seems to show a natural border at the back of the internal nares.

The maxilla is not well shown, but in its anterior portion bears a single row of very closely-set teeth which are wider from side to side than they are long; posteriorly the teeth are small, separated, and circular. The maxillary teeth seem to be thecodont, and are very short and blunt, being directly apposed to those of the lower jaw.

The quadrate is shown on the left side as a rather thick plate curved laterally, so that its inner border comes into contact with the front face of the posterior ramus of the pterygoid, and its thin outer border forms part of the outer side of the skull.

Lying to the outside of the quadrate, but with its thin posterior border within that bone, is seen the lower edge of a bone which is very short antero-posteriorly. This bone can only be a quadratojugal or a squamosal. Tightly applied to the outer surface of this bone is the extreme tip of another, which might be a squamosal if the other be a quadratojugal.

On the same side, lying in close relation to the posterior end of the maxilla, is an L-shaped bone which can only be the jugal; its border all round seems to be a natural one. From its curvature it is certain that the long limb cannot have reached back to the quadratojugal, but formed the back of the orbit, which must have been very large. As the squamosal and quadratojugal are in their natural position and the jugal is displaced, it seems certain that there was no lower temporal arcade and that the temporal region was cut away from below, as in lizards.

The lower jaw is in place and the left side of the palate is perfectly preserved, so that there is no difficulty in making a restoration of the palate. In such a restoration the pointed shape and width of the skull are very noticeable, as are the enormous interpterygoid vacuity and the fact that the articular region of the quadrate lies far in advance of the basioccipital.

The lower jaw of the right side is perfectly preserved and fairly well exposed. There is a small splenial entering the symphysis and overlapping the angular behind; the rather larger dentary overlaps the outer side of the same bone. The angular is a large boat-shaped bone forming the bottom of the jaw behind. The surangular and articular are not exposed, but on the left side a short, high, very lizard-like coronoid process lies outside the pterygo-transverse process.

The two rami are only loosely connected in front.

*Vertebral column.*—The anterior vertebrae are not known, having been in the other side of the block, which was not recovered. The whole skeleton lies in position, so that from measurements it is possible to obtain the length of the missing part; if, as seems most probable, the anterior vertebrae were of the same length as those behind them, eight are missing, giving a total of twenty-four presacra. All the presacra preserved are much alike in form and size. The centrum is small, with a wide hourglass-shaped notochordal canal running through it; it is expanded at the articular ends and somewhat constricted in the middle; the lower surface is rounded but slightly flattened. The arches are very wide and the neural canal enormous, much wider than it is high. The last presacral gives satisfactory evidence that the zygapophysial articulating surfaces were flat and placed horizontally; the anterior zygapophyses only project very slightly, if at all, in front of the centrum. The transverse process best seen in the 12th and 13th presacra is short, and extends from a point on the arch near or on the neurocentral suture up to the process which supports the prezygapophysis, but the articular facet for the rib begins some distance behind its anterior end. There are intercentra throughout the column except between the sacra. There are two sacra of the same length as the presacra; their centra are, however, more robust, and have a very pronounced carination of the lower surface. The sacral ribs are largely attached to the centra.

The first five caudal vertebrae, which alone are preserved, are of the same length as the sacra, but the centra are constricted and rapidly lose the carination of the sacra: there are apparently intercentra between the first and second and all succeeding caudals, but at what point these take the character of hæmal arches is not shown, although that between the 4th and 5th is a chevron bone.

*Ribs.*—The presacral ribs are all single-headed, holospondylous; their articular end is somewhat swollen but is not very broad, as it is in *Dicynodon* for example. The ribs are long, considerably curved, quite slender, and ribbed in front.

The anterior sacral rib is short and strong; it has a large flat surface for the ilium, and arises from the conjoint centrum and neural arch rather far forward. The posterior rib is longer, but perhaps not so strong as the anterior; it has a very large articulation with the ilium, and its distal end is in contact with that of the first sacral rib.

The caudal ribs of the first four vertebrae are long simple processes fused on to the body of the vertebrae.

There are faint traces of abdominal ribs.

*Pectoral Girdle.*—The pectoral girdle is in position, and so far as it is shown very well preserved.

The interclavicle is a large bone with a rhomboidal head produced at the lateral angles into short processes, and with a very long narrow stem. The head has its front edges bevelled off and

recessed for the clavicles, and the under surface of the stem is also recessed, apparently for the inner borders of the coracoids. This implies that the interclavicle largely lay above the coracoids, a feature only paralleled by the Plesiosaurs. The evidence for this curious arrangement is very much strengthened by the fact that the stem is broken, and the lower part with the right coracoid underlying it is pressed up, whilst the left coracoid retains its natural position in relation to the anterior end of the interclavicle.

The lower end of the left clavicle is well preserved; it is rather wide and thick, lies along the anterior border of the head of the interclavicle, and shows a very feeble sculpturing of pits and grooves. The coracoid and scapula of each side are fused together, and only the lower part of the joint-bone is exposed. The coracoid is a large flattish bone with curved borders; it bears a strong process which carries the lower and posterior part of the glenoid cavity, behind which the bone is continued for some distance. There is a small, oval, coracoid foramen in the groove which continues the glenoid cavity forward. There is a powerful rounded supraglenoid process borne by the scapula, and some slight evidence of a glenoid foramen. The right scapulo-coracoid shows that the whole bone forms about a quadrant of a circle. There is no reason to suppose that more than a single coracoidal element was present: this being no doubt, as Williston believes, the anterior of the two of the *Cotylosaur* shoulder-girdle.

*Fore limb.*—The upper part of the right humerus is shown from below; the left humerus is badly exposed, but shows the length of the bone and something of its distal end. The bone is very slender; it is slightly expanded at both ends, and no doubt somewhat twisted. The head is not well exposed; there is a short but relatively powerful radial crest which rather rapidly subsides on to the shaft. Of the distal end, all that can be said is that it is exceptionally well ossified and finished, with a round condyle for the radius, facing at right angles to the shaft, and a facet for the sigmoidal fossa of the ulna at the end.

The radius is a long slender bone slightly expanded at the ends. The ulna is a slender bone, with the upper end thickened and produced into a very pronounced olecranon process.

Although the carpus is only a centimetre square its structure is shown with diagrammatic clearness on the right side, where it is exposed on its palmar aspect and has the actual bone well preserved.

There are three large proximal carpals, and a slight suggestion of a small pisiform lying a little removed on the ulnar side. There are three centralia which completely separate the proximal and distal rows of the carpus. The most ulnar of these is very small, articulates with the ulnare, median centrale, and fourth distal carpal. The median centrale is one of the largest bones of the wrist, articulates with the ulnare, intermedium, radiale, radial centrale, third and fourth distal carpals, and the ulnar centrale.

The radial centrale is a large bone articulating with the radiale, median centrale, and the first three distal carpalia. There are five distal carpals, all except the fifth being large bones in mutual contact. The fifth is a smaller bone, forming only part of the support of the fifth metacarpal. The carpus as a whole is remarkable for its thorough ossification and the accuracy of fit of its elements.

Text-figure 2.

*Broomia perplexa.*

Outline drawing of right carpus and manus as preserved.

R. Radius. U. Ulna.  $\times 2$  approx.

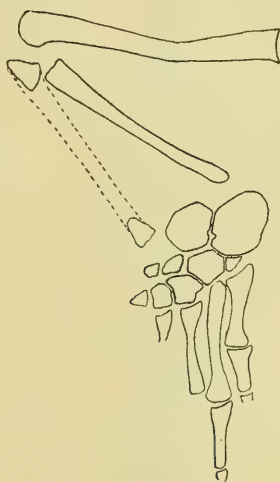
*Ilium*.—Neither ilium is quite complete, but the two supplement one another so as to give a good idea of the whole bone. There is no preacetabular projection, the blade of the bone extending upwards and backwards from the strong process which projects over the acetabulum. The outer surface of the bone has a strong ridge running horizontally across it, and the upper end shows a faint grooving for muscle-insertion.

The pubis and ischium cannot be exposed.

The left femur is only shown in section, but the right gives some idea of the form of the bone. It is slender and sigmoidally curved. The articular facet at the distal end is well rounded; the upper end of the bone is flattened, but bears a strong trochanteric ridge. The tibia and fibula are very slender bones shown only in section. The left tarsus is beautifully shown; it has the bone preserved and is exposed on its dorsal surface. Its

proximal row consists of two very large flat bones which meet in the middle in a long articulation broken by notches which together form a small foramen. One of these bones is the fibulare, the other in all probability the fused tibiale and intermedium. The distal row consists of five bones, of which the fourth is very large and articulates with the two proximal tarsals. The first, second, and third distal tarsals are separated from the tibiale intermedium by two centralia which form a median row in the tarsus.

Text-figure 3.

*Broomia perplexa.*

Outline drawing of the left hind leg as preserved.  $\times 1$ .

The first metatarsal is not exposed; the base of the second is seen supported by its tarsal. The third is a slender bone of considerable length. The fourth is even longer, being more than half as long as the fibula. The fifth metatarsal is short, only slightly more than half as long as the fourth. In the specimen all the metatarsals lie parallel and close up to one another.

This little animal, as restored in text-fig. 4, is thoroughly lizard-like in build and obviously led a lizard-like life on perfectly dry land. It may perhaps, as suggested by its large claws and very slender limb, have been to some extent arboreal.

The little lizard-like animal, almost the whole of whose structure is described in the foregoing account, is obviously distinct from any known South African form, and as it is the most striking new form which I collected in that country, I propose

for it the name of *Broomia perplexa*, gen. et sp. n., in token of my admiration of Dr. R. Broom's work on early Tetrapods. In

Text-figure 4.



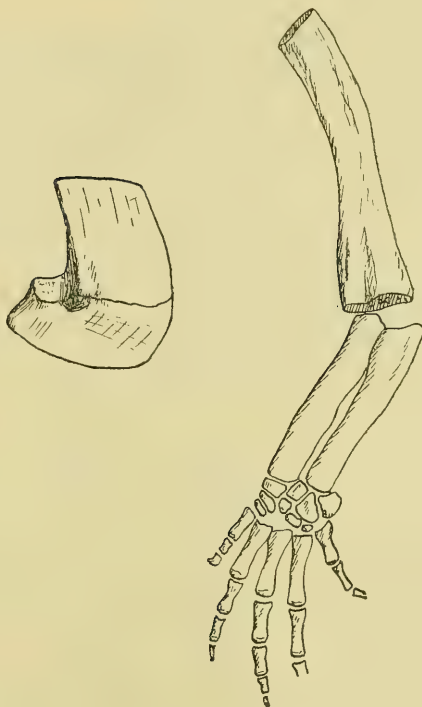
*Broomia perplexa.*

Restoration of the skeleton from the ventral aspect with the abdominal ribs omitted.  $\times \frac{1}{2}$ .

discussing its systematic position it will, I think, be most convenient to compare it in detail with all the great groups of

early reptiles which are well enough known to make a comparison of much value, and then to discuss some of the less known Permian types which resemble it.

Text-figure 5.



*Adelosaurus huxleyi* (Hancock & Howse).

Left fore limb and right scapulo-coracoid.  $\times 1\frac{1}{2}$ .

From the type-specimen in the Hancock Museum, Newcastle-on-Tyne.

#### *Comparison with Cotylosaurs.*

The palate with its abundant armature of teeth is somewhat similar to that of the Captorhinidæ, in which the distribution of the teeth and even some details, such as the shape of the pterygoids and the length of the parasphenoid, are identical.

The basisphenoid of *Broomia* differs, however, from that of all known Cotylosaurs in its very great breadth and only very slightly marked tubera. If, as seems probable, the side wall of the skull was cut away in *Broomia*, we have a very striking

difference, but one which the example of the *Chelonia* teaches us might have occurred very rapidly.

The vertebral column of *Broomia* is very similar to that of the Captorhinids, having small completely perforated centra, heavy neural arches and horizontal zygapophysial articulations, and small intercentra. The rib articulations, however, are smaller in our type.

The limb-girdles of *Broomia* are totally unlike those of any Cotylosaur in their great slenderness. The shoulder-girdle differs very markedly from that of the Captorhinidae, but faintly recalls that of *Seymouria* in its peculiar interclavicle with a diamond-shaped head and in the clavicle with its curious expanded lower end. The loss of the posterior coracoidal element is paralleled by *Seymouria*, but in that type if I interpret Prof. Williston's description accurately, the real Coracoid was present although it was not ossified and contributed to the glenoid cavity, which, as in the majority of Carboniferous reptiles, had the peculiar screw-shaped form most typically shown in *Diadectes* and *Eryops*. Traces of this former possession of this type of glenoid cavity are to be seen in *Broomia*, but the conditions there are different, in that the whole glenoid cavity is carried by the scapula and the single coracoidal element, which extends backward for some distance behind it.

The humerus is distinguished from that of any Cotylosaur by its slenderness, but is probably structurally similar to that of *Captorhinus*.

The carpus of *Broomia* is unique, no other form being known in which the centralia completely separate the proximal and distal rows of carpals.

The ilium, which alone of the pelvic bones is known in *Broomia*, differs from that of all Cotylosaurs in its slenderness and its sloping anterior border.

The femur is so badly exposed that it is difficult to compare it with that of Cotylosaurs, from which, however, it differs in its extreme slenderness. The tarsus differs from that of any known Cotylosaur in the presence of two centralia.

These resemblances, particularly those in the vertebral column, seem to show that *Broomia* has descended from some Cotylosaur; the differences, lying chiefly in the build and limb-skeleton, are in general advances of an adaptive nature, but the tarsus is the most primitive known amongst reptiles, and the carpus cannot at present be explained.

#### *Comparison with the Therapsid stock.*

*Varanosauros* and its immediate allies amongst the Poliosauridae are the most primitive known members of the Therapsid line, and as they are comparatively small and lightly built reptiles, offer an exceptionally favourable field for comparison with *Broomia*.

The palate of *Broomia* is not very unlike that of *Varanosaurus*, but differs in the wide basisphenoid, the very large interpterygoidal vacuity, and the more abundant teeth. The lower jaw of *Broomia* is quite distinct from that of any Therapsid in that it has a boat-shaped angular in place of the characteristic flat-notched angular of the Therapsid. The vertebral column is also somewhat similar to that of a Poliosaurian, but the neural arches are heavier and the rib articulations not so wide. The shoulder-girdle differs in that the shoulder-girdle of the Therapsids always has a posterior coracoidal element which may be only cartilaginous but contributes to the glenoid cavity.

The ilium of *Broomia* is strikingly like that of *Pacilospondylus*, and not unlike that of *Varanosaurus*. The foot resembles in some ways that of *Varanosaurus* and is almost identical with that of *Ophiacodon*, which Prof. Williston believes to belong to that group.

The difference in the lower jaws shows at once that *Broomia* does not belong to the Therapsid line, and the resemblances between *Varanosaurus* and *Ophiacodon* and *Broomia* seem to be in general either primitive features or adaptive ones.

I have compared *Broomia* with *Casea* but see no special resemblance between them. (*Casea* is perhaps an extremely early offshoot from the Therapsid stock before it had acquired its characteristic angular.)

*Broomia* has an obvious superficial resemblance to *Aræoscelis* in that they are both very lightly built reptiles of small size. It is at present difficult to compare them in detail. From the published accounts of Williston I have been able to find the following resemblances:—

In both there are teeth on all the bones of the palate. If Broom's *Ophiodeirus*, founded on the specimens of "*Bolosaurus*" figured by Case, is really *Aræoscelis*, then there is a very striking similarity in the palate of the two types, in the large interpterygoidal space, very long parasphenoid, and general structure. The dorsal vertebræ are similar in their slender notochordal centra and heavy arches. The ribs are similar in having only a single slightly expanded head which articulates with the arch and centrum near the front end of the vertebra throughout the series. The sacrum of *Aræoscelis* is said to be almost indistinguishable from that of lizards; that of *Broomia* also resembles the same forms. The tail is long in both types.

I can find no characters in which the incompletely known humerus of *Broomia* differs from that of *Aræoscelis*. The femur and tibia of the two types seem to agree.

The more important known differences between the two types are that *Aræoscelis* retains the primitive two coracoidal elements and that there is no trace in that type of the cut-away side of the skull of *Broomia*. At the same time it must be remembered that the facts are not certainly known in our fossil and that the jugals of the two forms have a considerable resemblance.

On the whole, there is nothing in the known structures of these two animals to prohibit a fairly close resemblance between them, but until Prof. Williston's full description is published it is impossible to go beyond this.

By far the most interesting comparison is between *Broomia* and a lizard.

It is certain that the lizard palate must have been derived from one generally resembling that of *Broomia*, and it is probable that it may have specially resembled that type in the possession of a very large interpterygoid vacuity and a very large parasphenoid.

The basisphenoid of *Broomia* at once recalls that of a lizard, but I know of none that really resembles it.

The lower jaw of *Broomia* is sufficiently generalised to have given rise to that of lizards, and very characteristic of that group is the short upstanding coronoid process.

If the side of the temporal region of the skull be really cut away in *Broomia*, we have a very striking resemblance to the Lizard type, where the narrowing of the primitively single arch has produced the well-known present-day structure.

The geckos have notochordal centra and intercentra, as has *Broomia*.

The articulation of the single-headed rib of *Broomia* is essentially similar to that of a lizard. The sacrum is also similar in the two groups of reptiles.

The pectoral girdle of *Broomia* is extraordinarily similar to that which the primitive lizards must have possessed in the following features:—

The reduction of the coracoidal elements to one on each side: this being, as Prof. Williston has pointed out, the anterior of the two of primitive reptiles.

The long slender interclavicle with a rhomboidal head is a type from which the characteristic cross-shaped interclavicle of a lizard could be derived. A T-shaped interclavicle could not have produced this form.

The somewhat expanded lower end of the clavicle is also a feature which was apparently present in the early lizards.

There is nothing specially characteristic about the bones of the fore-leg in lizards, and they could be derived from those of *Broomia*.

The carpus of *Broomia* differs as much from that of any lizard as it does from that of all other reptiles.

The ilium of *Broomia* is completely lizard-like in its antero-ventral slope. The hind leg of *Broomia* is not specially lizard-like.

The only feature which we would expect to be present in an ancestral lizard which does not occur in *Broomia* is that modification of the fifth digit, perhaps a divarication, which led to the modified fifth metatarsal found in Lizards, *Sphenodon*, Chelonia, Thecodonts, Crocodilia, etc.

The skeleton of *Sphenodon* is so thoroughly lizard-like that *Broomia* resembles it nearly as much as it does a lizard, but there is pretty clear evidence that there was not a lower temporal arcade like that of *Sphenodon*.

The only other group with which it seems necessary to compare *Broomia* is the Mesosauria. The skull is unknown in this type. The vertebræ differ in their much more massive arches, and in the mode of articulation of the ribs. The pectoral girdles of the two types are generally similar, but the interclavicle of *Mesosaurus* is T-shaped. The carpus differs by the absence of centralia in *Mesosaurus*. The pelvis differs in the shape of the ilium. The tarsus differs in the complete loss of centralia in *Mesosaurus*. It thus seems certain that the two types have little to do one with the other.

Only two, *Heliosaurus* and *Heliophilus*, of the little-known types from South Africa agree at all with *Broomia*.

*Broomia* resembles them in the following features:—

1. The sharply pointed but relatively short skull.
2. The shape of the pterygoid in *Heliosaurus*.
3. The position of the quadrate in advance of the basioccipital condyle in *Heliosaurus*.
4. The presence of a distinct neck.
5. The presence of intercentra throughout the vertebral column.
6. The heavy neural arches.
7. The single-headed ribs.
8. The similar number of presacral vertebræ.
9. The shoulder-girdle of *Heliosaurus* much resembles that of *Broomia*.
10. The slender limbs.

These resemblances, although they are to some extent due to the retention of primitive features, do seem to show that there is some real connection between the three animals. In *Heliosaurus*, however, as Broom has shown, there is some evidence of the presence of a quadratojugal arcade, which is apparently lacking in *Broomia*. When I examined the type-specimen of *Heliosaurus* some time ago I was not specially interested in it, but even at that time thought it conceivable that the apparent lower arcade might be the upper edge of the lower jaw. *Heliosaurus* is of interest because of the presence over its dorsal region of small bony scutes identical with the osteoderms of lizards.

Of the European forms, *Aphelosaurus* and *Kadaliosaurus* from the Lower Permian, and *Proterosaurus* and the animal known as *Proterosaurus huxleyi* from the Upper Permian, present some resemblance to *Broomia* in that they are slender lizard-like reptiles. *Kadaliosaurus* from the Rothliegende of Dresden is regarded by Prof. Williston, who has examined its remains, as being extremely similar to *Aræoscelis*: in fact, he stated that there

are no visible differences between them; it need not, therefore, be further considered.

*Aphelosaurus* is unfortunately very little known, but its shoulder-girdle seems very similar to that of *Broomia* in the large size of the coracoidal part. The slender limbs, however, differ in the fact that they are all of much the same length, and also in the much greater narrowness and compactness of the tarsus.

The animal is, in fact, so incompletely known that little can be said about it.

*Proterosaurus* is a very interesting form which is, however, still very little known.

The skull, as known from the single, very imperfect example in the College of Surgeons Museum, is pointed and has teeth on the palate. There is apparently no evidence of the presence of an upper temporal vacuity, and nothing can be said of the condition of the temporal region. It differs from *Broomia* in its very long neck and in the enlarged cervicals.

The vertebræ differ in their light neural arches, but the rib articulation is essentially similar in the two types. The sacrum is fairly well preserved in the Newcastle Museum specimen from Fulwell, Durham; it is composed of two vertebræ carrying large sacral ribs which resemble extremely those of *Pœcilospondylus* as figured by Case, and to a less extent those of *Broomia*.

The shoulder-girdle has a very large, presumably single, coracoidal element, and a rather slender scapula. The large interclavicle, with an expanded upper end, is not altogether unlike that of *Broomia*.

The limbs are considerably more massive than those of *Broomia* and are still very imperfectly known, and, as in that type, the hind limbs are considerably larger than the fore.

On our present knowledge of *Proterosaurus* it is impossible to be certain of its systematic position, but it appears not improbable that it has something to do with *Broomia*.

The animal described by Howse and Hancock as *Proterosaurus luxleyi* is quite distinct generically from *Proterosaurus* and may have no real connection with that animal.

It is a small form with a long neck in which, however, the cervicals are not elongated. The centra are large and biconcave and the arches heavy. The ribs are single-headed. There are apparently intercentra present. The shoulder-girdle is fairly well shown. The scapula is a bone with no special features, and the single coracoidal element is very large and singularly lizard-like. The clavicle has an expanded lower end. The limb-bones are incompletely ossified.

The humerus is remarkable for the very slight expansion of its extremities and the absence of a definite crest.

There is a small entepicondylar foramen.

The radius and ulna are small bones with no particular characters.

The left carpus is perfectly preserved.

There are four large proximal carpals and two well-ossified centralia, the radial of which forms part of the border of the carpus.

There are only three distal carpals, the first, third, and fourth, but there is an obvious space for the second, which was either cartilaginous or has dropped out. There is certainly no fifth carpal. The metacarpals and phalanges are relatively rather massive and taper rather rapidly. It is possible that the fifth had only two phalanges.

The ilium is a small bone, only the inner aspect of which is known but whose outline is like that of *Belodon*.

The affinities of this animal, for which the new genus *Adelosaurus* may be founded, are quite obscure; the fore limb is not very unlike that of *Sphenodon* in some features, and it is not improbable that the type may be connected with an Archisaurian stock.

The preceding discussion will, I think, have shown that *Broomia* cannot be placed in any of the well-known Orders of reptiles which occur in the Permian rocks of the world. It seems not improbable that it is connected in some way with the earlier *Aræoscelis* and with the later lizards, but the absence of all knowledge of the temporal region of the skull and what is probably still more important, of the neural cranium, makes this resemblance rest on a very insecure foundation.

Comparison with other slender-limbed Permian forms, so far as is possible from the very imperfect material available, shows that whilst there are certain general resemblances between them there are also many important differences which make it very inadvisable to definitely group them together.

The fact that, whilst we know almost the whole structure of *Broomia*, we are incapable of doing more than guess at its affinities, owing to the absence of knowledge of the upper part of the skull and of the brain-case, shows how very few are the characters on which we really rely in estimating the affinities of a reptile.

I am indebted to the Percy Sladen Trustees for assistance in visiting South Africa, and especially to G. Gordon, Esq., of Hottentots Rivier, to whose interest and hospitality I owe, not only the beautiful skeleton of *Broomia*, but also many other fine specimens. I have to thank the authorities of the Northumberland and Durham Natural History Society and Mr. E. L. Gill, the Director of the Hancock Museum, for permission to examine the type-specimen of "*Proterosaurus huxleyi*."

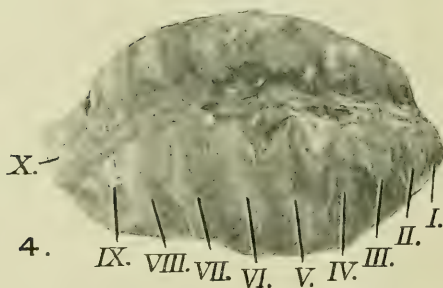
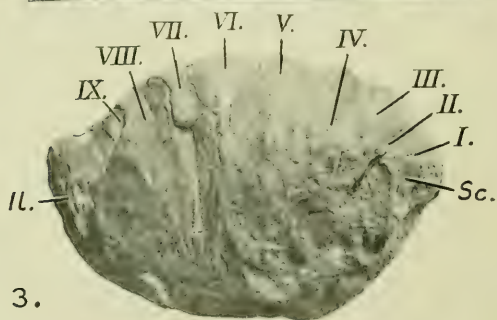
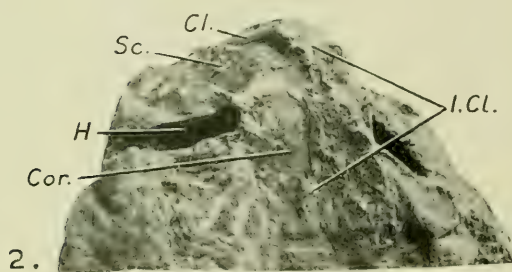
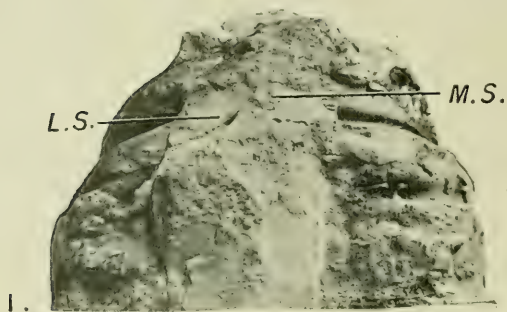
Finally, I wish to thank Mr. Pittock, of University College, for the excellent photographs from squeezes, and Mr. H. E. Herring for the photograph of the block.

## EXPLANATION OF PLATE VI.

*Broomia perplexa*, gen. et sp. n.

- Fig. 1. Untouched photograph of a squeeze of the palate of the type-specimen.  $\times 1\frac{1}{4}$ .  
In this figure the matrix was covered with a thin wash of white before the photograph was taken.
2. Pectoral girdle. Photograph as in fig. 1.  $\times 1\frac{1}{5}$ .
  3. Middle dorsal vertebrae. Photograph as in fig. 1.  $\times 1\frac{1}{5}$ .
  4. Sacrum. Photograph as in fig. 1.  $\times 1\frac{1}{5}$ .
  5. Left ilium. Photograph as in fig. 1.  $\times 1\frac{1}{4}$ .
  6. Photograph of the actual specimen.  $\times 1$ . Showing the right hind leg, posterior pre-sacral vertebrae, the last three showing clearly the immense size of the neural canal, the sacrum, and the caudal vertebrae.





Bale & Danielsson, L<sup>td</sup> imp.

EUNOTOSAURUS AFRICANUS.

53. *Eunotosaurus africanus* Seeley, and the Ancestry of the Chelonia. By D. M. S. WATSON, M.Sc., F.Z.S., Lecturer on Vertebrate Palæontology in University College, London.

[Received June 3, 1914: Read November 24, 1914.]

(Plate VII.\* & Text-figure 1.)

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The great group of the Chelonia is of unusual interest, because it is the only example of a persistent and world-wide Order whose structure is entirely dependent on a bizarre specialization: the development of the shell.

Tortoises are first known from the Upper Trias of Germany, where they are represented by extremely typical and apparently not markedly primitive forms.

By an analysis of the structures common to all Chelonia, it is possible to form some idea of the chief features which must have been present in the ancestors of the group. Although it is impossible to determine whether or not these characters were actually all present together in any type, it will be convenient to add them together to form an imaginary animal which may be called "Archichelone."

*Skull*.—The skull of the Chelonia has been discussed by many authors, most recently by Hay, whose conclusion is adopted in this paper.

Since the description of *Sphenodon* by Dr. Günther, it has been repeatedly pointed out that, in such a type as *Chelone* with a completely roofed skull, the four bones—post-orbital, squamosal, jugal, and quadratejugal—which form the lateral temporal arcades of *Sphenodon* are present. If I do not misinterpret their opinions, most of those who have discussed the subject believe that the skull of *Chelone* has actually arisen from a two-arched form by a secondary enlargement of these bones, until they unite by their edges. This conclusion is rendered improbable by the fact that some Cotylosaurs, *Labidosaurus* and *Pariasaurus* for example, whose skulls have certainly always been completely roofed, have an identical arrangement of bones in the temporal region.

In many Chelonia, apparently without any correlation with the animal's habits other than the power of retracting the neck, the temporal region is open; but this opening never results in the formation of a two-arched form—in all cases it has been

\* For explanation of the Plate see p. 1020.

arrived at by the eating away of a solid cranial roof either from the back or from below. The former process results in the loss of a parieto-squamosal connection and the retention of that between the jugal and quadratojugal, as in *Trionyx*: the latter produces a skull like that of *Chelys*, in which the squamoso-parietal connection alone persists. Extension of either process results in the complete loss of both connections, as in *Cistudo*.

The only view which really fits the case is that the primitive Chelonian skull was completely roofed like that of *Chelone* or a Cotylosaurian reptile. This view is supported by the preponderance of roofed skulls in early fossil forms.

It is not at all difficult to derive the Chelonian skull from that of a Cotylosaurian reptile. The chief differences in the palate, the total loss of teeth, the reduced pterygoids and their firm union with the basis cranii, and the rudimentary secondary palate, are apparently dependent on the gradual development of the horny beak. The unrelated group of the Anomodontia (Dicynodontia) show the gradual extension of a horny beak, followed by the total loss of teeth, the reduction of the pterygoid and its close union with the basisphenoid, and the development of a small secondary palate which in such features as the fusion of the prevomers is extremely like that of a Chelonian.

Many of the peculiar features of the posterior part of the Chelonian skull are due to the necessity of adequately supporting the very powerful vertically placed quadrate.

Other remarkable features in which all Chelonians agree are the loss of the postfrontal and prefrontal (or lachrymal), and the usual absence of nasals; with the exception of the last, these losses have repeatedly occurred amongst reptiles. A much more striking feature is the loss of the facial processes of the premaxilla, so that the bony external nares are united. This change is only paralleled in the Mammalia, of which group it is one of the most striking peculiarities.

"Archichelone," then, had a roofed skull with a primitive reptilian palate, teeth, probably only a squamosal of the temporal elements [and no facial processes of the premaxilla].

*Neck*.—Cope pointed out that all tortoises could be divided into two classes according to the mode of retracting the neck, either vertically in the Cryptodeira (to which may be added the Trionycids and *Dermochelys*) or laterally in the Pleurodeira. This feature to all appearances affords a foundation for an absolute division of all known types, a fact the meaning of which is plain. "Archichelone" must have had a long and flexible neck, capable of bending in all directions; and after the development of the shell, when it was desirable to withdraw the head for protection, the two lines gradually became distinct, any intermediate conditions being obviously mechanically undesirable.

As all known Chelonians have eight cervical vertebrae we are justified in claiming that number for "Archichelone."

*Trunk*.—In the discussion of the trunk I shall disregard

*Dermochelys*, as the evidence now seems conclusive that that type has originated in Tertiary times from a Cryptodeiran ancestor. In all Chelonia the trunk is very markedly separated from the neck and tail, being very broad and completely surrounded by the shell. The shell of all Chelonia in which it is not reduced has the following structure :—

There is a median dorsal row of dermal plates. There is always a nuchal, sometimes a postnuchal, then eight or fewer neurals and one or two pygals. The whole of this series seems to be homologous, but the eight neurals are distinguished from the other median elements by their definite correlation with the neural spines of the dorsal vertebræ. It seems certain that at one time the nuchal etc. were also directly associated with the anterior and posterior dorsal and sacral vertebræ, and that they lost this primitive connection after the formation of the shell, either by its exaggerated growth or by a shortening of these regions of the vertebral column, so as to allow of the retraction of the head and limbs within the shell.

All Chelonia have a row of costal plates on each side of the neurals; these are invariably eight in number and are fused with the dorsal ribs from the second to the ninth. The development of these plates shows that they are of purely dermal origin, and they may be directly compared with the paired scutes found in Crocodiles and many allied reptiles.

The fact that they have only fused with eight of the ten dorsal vertebræ shows that these segments in "Archichelone" were in some way specialised and distinguished from the first and last dorsals.

The marginal elements of the shell are not correlated with the ribs, and perhaps represent a different order of scutes as is suggested by Versluys.

The plastron of Cryptodeires and some Pleurodeires consists of a single median and four pairs of plates. In most Pleurodeires and Amphichelydia an extra pair of plates is inserted, and in the remarkable Triassic *Protochersis* recently described by Fraas two extra pairs.

The median and the anterior pair of plastrals are universally recognised as the interclavicle and clavicles. The other pairs are usually homologised with ventral ribs: that they resemble the latter in being ventral dermal ossifications is of course true, but I do not think it at all follows that they are necessarily derived from them.

There is, for example, never any trace of a median or other lateral rows in the plastron of Chelonia, whilst abdominal ribs usually have an angulated median and more than one lateral row of elements.

Furthermore, as "Archichelone" certainly had a series of dorsal scutes comparable to those of a crocodile, it is by no means unlikely that it resembled many members of that group in having ventral scutes not homologous with abdominal ribs.

The fact that in early times tortoises with mesoplastra were proportionately commoner and more widely spread than to-day, and that Triassic forms may have two pairs of mesoplastra, suggests that the number in still earlier forms was even greater, and possibly derived from a condition in "Archichelone" where there was a pair of plastrals to each segment of the middle dorsal region.

The fact that adaptation to aquatic life almost always implies degeneration of the shell in Chelonia, shows conclusively that "Archichelone" must have been a land form.

*Limb-girdles.*—The most striking feature of the limb-girdles of Chelonia is that they lie within the shell and ribs. It is plain that this condition was gradually acquired after the development of the shell by the migration of the pectoral girdle backwards, and that further growth of the front and back of the shell which we have already found necessary to account for the dissociation of the nuchal and pygal elements from the vertebrae to which they probably originally belonged. The whole arrangement is designed to allow of the retraction of the limbs for protection.

In "Archichelone" the pectoral girdle was undoubtedly in the usual position overlying the first dorsal ribs, and must have been narrow relatively to the bulk of the trunk to allow of its passage back within the ribs.

The pelvic girdle must also have been very narrow.

This shows that the neck and tail of "Archichelone" must have been sharply marked off from the trunk by their smaller diameter.

It is impossible to discover the structure of the limb-girdles of primitive Chelonia from those we know; the pectoral girdle of a Triassic type recently described by Jackel shows that the huge acromion, which is one of the most striking peculiarities of the ordinary form, has arisen in comparatively recent times. There can be no reasonable doubt but that the girdles of "Archichelone" were of what Prof. Williston calls the "old fashioned" type, *i.e.*, that there were two coracoidal elements and the pelvis was "plate-like."

*Limbs.*—From a study of the mode of walking of land Chelonia it seems to be possible to arrive at some conclusions as to the type of limbs present in "Archichelone." In tortoises the fore arm and leg are carried nearly at right angles to the upper arm and thigh and stand almost vertical, sometimes even standing over at the elbow. The humerus and femur are carried nearly horizontally and very seldom depressed below the level. The animal sways from side to side, so as to bring its centre of gravity within the area of support afforded by the three legs it stands on whilst the fourth is advanced.

Some of these features, the standing over at the elbow for example, are obviously due to the development of the shell; but, even if allowance be made for this, there remains sufficient to suggest that the Chelonia were derived from a group with the type of humerus found in *Eryops* and *Dimetrodon*, which had a

gait of similar character, the humerus being never depressed below a horizontal position and moving in a plane which, although it does fall towards the back, is more nearly horizontal than vertical. These animals certainly swayed from side to side whilst walking.

The Chelonian humerus can be directly derived from the reptilian humerus as represented by *Varanosaurus*. The rounded and upturned head is an obvious adaptation to the retraction of the limbs. The narrow distal end, so different from the wide epicondylar region of the early forms, depends on the reduction of the muscles which lie along the lower surface of the fore arm, and are inserted on the entepicondyle, following on the habit, induced by the developing shell, of carrying the fore arm vertically.

The short, powerful, downwardly directed radial and ulnar crests seem to depend to some extent, though not completely, on the development of the shell as a source of muscle-attachments.

We may, in fact, take it as probable that "*Archichelone*" had limbs more or less like *Eryops* or *Varanosaurus* or *Dimetrodon*.

*Eumotosaurus africanus* Seeley is at present represented by five specimens, one of which is in the South African Museum, Cape Town, and the other four in the British Museum (Natural History). All these specimens agree in including only the dorsal region of the animal, and except in the case of the type are preserved in nodules, so that in transverse section the ribs form an oval rather higher than wide.

The most nearly complete is No. R. 4054, B.M.N.H. (Pl. VII. figs. 3 & 4). This is preserved in a very hard nodule and shows the general shape. At the anterior end a scapula is in place on one side; on the other end of the specimen we have the impression of the anterior face of the first sacral ribs and of the anterior border of the ilia. The specimen is thus of importance, because it shows that the entire dorsal region is preserved.

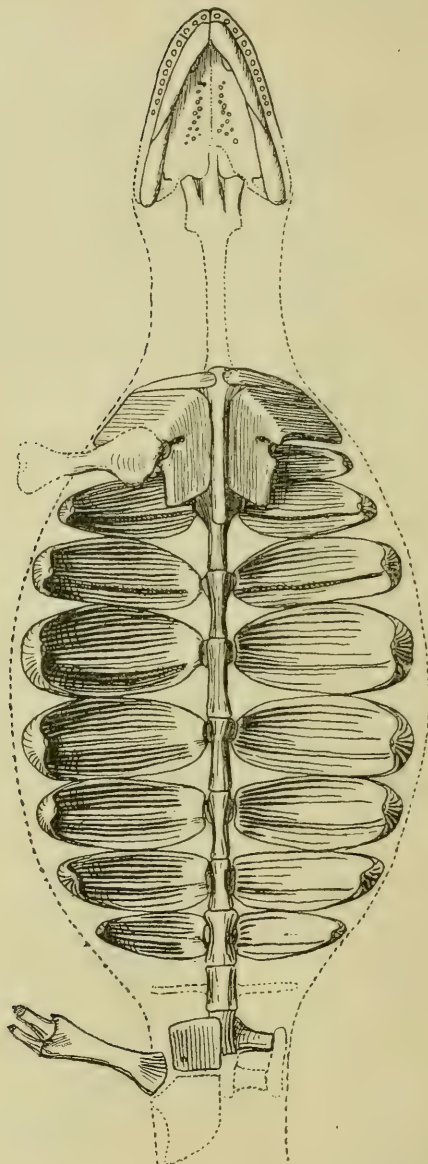
No. 49424, which is also preserved uncrushed in a nodule, is not quite complete behind, but in front the shoulder-girdle is shown in part. The skull lies with its ventral surface in contact with the ventral surface of the body and with its anterior end pointed backwards, with the lower jaw articulated.

Weathering has removed the whole skull to within about a millimetre of the dorsal surface of the palate and in the middle has even removed the bone from this, leaving a somewhat faint impression. This specimen is important, because it alone shows the skull and because the position of the head is only possible if the neck were fairly long and flexible.

No. 49423 (Pl. VII. figs. 1 & 2) is a specimen about twice the size of the preceding two, and like them preserved uncrushed. It shows, well preserved, the whole shoulder-girdle and also impressions of the humeri from which the bone has weathered away. It also shows traces of scutes.

No. R. 1968. The type-specimen differs from all the others in

Text-figure 1.

Restoration of *Eumotosaurus africanus*.

that it is preserved in a relatively soft matrix and has been so macerated before burial that the ribs have twisted round on their articulations so as to lie nearly flat.

It shows one pubis and a femur, tibia, and fibula.

*Skull.*—The skull is very incompletely and rather badly preserved.

The basisphenoid is broad and provided with basiptyergoid processes directed forwards in the plane of its flat lower surface. There is a rather wide parasphenoid.

The quadrate clearly lies considerably in advance of the occipital condyle. There are numerous teeth on the palate, some scattered, but most forming a ridge on the pterygoid. The choanæ are rather large and separated by wide bars of the prevomers, lying close up to the maxillæ and premaxillæ.

The maxilla is provided with a single series of small round (?) teeth, of which about eight are shown.

The premaxillæ also bear teeth, apparently three in each.

When I first saw the specimen the whole of the extreme anterior end of the skull was covered by matrix, which I removed with a needle under a Zeiss binocular dissecting microscope. Whilst doing so I found no trace whatever of any internarial processes of the premaxillæ, and believe them to have been certainly absent; the anterior nares are consequently confluent and look directly forward.

The lower jaw is present but not sufficiently well shown for description.

Except for the evidence given by specimen No. 49424, that the neck was relatively long and very flexible, nothing is known of this part.

R. 4054 which, as shown by the position of the limb-girdles, has a complete dorsal region, has ten dorsals. These are all fairly similar in structure. The first is short, the second somewhat longer, and the third very long. The fourth, fifth, and sixth are about as long as the third, and the seventh to the tenth show a progressive diminution in length. The structure of the individual vertebræ is best shown by the type-specimen. The centrum is very slender, particularly in the fourth to seventh dorsals, and somewhat hourglass-shaped; it is completely pierced by the notochordal canal. The rib-facet is carried on a very low and small process which in the middle dorsal region is placed at the extreme anterior end of the centrum, whilst anteriorly and posteriorly it travels back to the middle of its length. The neural arch is rather massive when compared with the centrum but is still very narrow. It bears very narrow zygapophyses which seem to interlock strongly. The upper surface of the neural arch is essentially flat, the spine being represented only by a low median ridge. The whole arch appears to be placed very far forward on the centrum and may overlap on its anterior end. There is no definite transverse process, but the ribs seem to touch the sides of the neural arch.

The first dorsal rib is a narrow, slightly bent, and quite short bone of an ordinary character. The remaining dorsal ribs, from the second to the ninth, are of an extraordinary character. Each is strongly curved, articulates by a facet on its proximal end with the face on the centrum, and then rises, until its upper surface comes in contact with the neural arch; there is no definite tuberculum and the capitulum is extremely feeble. The rib then rises above the level of the neural spine so that the dorsal surface of the vertebral column lies at the bottom of a groove formed by the proximal ends of the ribs. The rib now turns outwards and downwards. The ribs widen very rapidly from the capitulum, so that until just at the point where they turn downwards their lateral borders actually touch. They are of a massive character throughout, and each is strengthened by the development of a ridge along its visceral surface.

The rib of the tenth vertebra is not known, but was certainly not expanded like those which preceded it.

The sacral rib is short and stout.

The shoulder-girdle is well shown in 49423. In this individual the bones of each side have fused, forming a scapulo-coracoid which rather strikingly resembles that of *Procolophon*. The scapula has a fairly narrow blade with a straight anterior edge, which has no specialised acromion. The precoracoid is a bone of triangular shape lying flat on the ventral surface. This results in the scapulæ being set not, as usually, in planes parallel to the principal plane of the body, but inclining together in front, so that the opening between them towards the neck is very much narrower than that towards the dorsal region. This implies that the neck was narrow.

The precoracoid apparently contributes to the glenoid cavity, and is pierced by a foramen which, exactly as in *Procolophon*, is protected by a rounded ridge along its front border. The coracoid is a small bone extremely like that of *Procolophon*.

The clavicle is a narrow bone running down the entire front edge of the scapula and then turning slightly in to the interclavicle.

The interclavicle is a long slender rod with a slightly expanded anterior end which is covered by the inner ends of the clavicles.

The humerus is only incompletely shown.

The nearly complete immature bone in 49424 is badly preserved, but shows that the bone is narrow and suggests that the deltoid crest was small.

The impressions in 49423 show that there was a definite head which is slightly upturned, and that there was an unusually large but very short ulnar crest.

The pelvis is represented by the badly preserved impressions of the anterior borders of the ilia (and pubes?) in R. 4054, and a perfect pubis in the type. The ilia have a narrow and straight anterior border and are as high as the space between them. The

pubis is a small square bone with a foramen, and shows that the pelvis was plate-like.

The femur of the type is a slender sigmoidally curved bone with not very well ossified ends and no very marked characters.

The tibia and fibula stand in the specimen at right angles to it; in natural articulation their short stumps present no features of interest.

Dermal bones are only shown in 49423.

In this individual, in the anterior dorsal region a small patch of what is undoubtedly bone substance is shown lying at a considerable distance above the ribs and neural arches. This is clearly divided into pieces, one of which forms a small round ridge in the middle line. The rest of the patch shows a dividing line running longitudinally and a transverse division apparently coincident with the line where the two ribs below it meet. On the posterior end of the specimen, at the same distance above the ribs, a narrow line of bone is seen in transverse section. This specimen gives conclusive evidence of the actual presence of dermal ossifications; but these are so incompletely preserved as to make any statements of their distribution of very slight value. There seem, however, to have been a median series and lateral rows.

The other specimens have no matrix preserved outside the ribs, so that the scales cannot be seen in them.

The chief features of the structure of Eunosauria as shown by these specimens may be summarised as follows:—

The skull is small, with a wide basisphenoid, a palate of the ordinary primitive reptilian type with many teeth, teeth in the maxillæ and premaxillæ. The external nares are confluent, there being no internarial processes of the premaxillæ. The neck is very flexible and sharply marked off by its narrowness from the trunk.

There are ten dorsal vertebræ of a slender character with nearly obsolete neural spines and with rib-facets far forward on the centra.

The first and last dorsal ribs are of an ordinary character, but the remaining eight are so extremely broadened as to touch one another by their edges. As shown by the uncompressed specimens, particularly R. 4054, the dorsal region was strongly convex, and the body was nearly circular in section.

The very small relative size of the pelvis shows that the tail was separated from the trunk by its much inferior diameter.

The pectoral and pelvic girdles are of ordinary "old-fashioned" type.

The dorsal region is covered with dermal ossifications, of which there are apparently median and lateral series.

It will be noticed that so far as the structure is known, *Eunosaurus* agrees exactly with the hypothetical "Archichelone" arrived at by a discussion of the structure of the known Chelonia.

Not only is this the case, but in many respects it has a resemblance in details even to modern Chelonia which is very remarkable. For instance, the long and extremely slender vertebræ are quite tortoise-like, and in the fact that the capitular facet is placed very far forward on the centrum we have a suggestion of that inter-central rib-articulation which is so striking a feature of the mid-dorsal region of modern Chelonians. The way in which this rib-articulation travels backwards on the posterior dorsals is exactly similar to the condition in *Homopus*. The anterior position of the neural arch on each dorsal centrum is prophetic of the modern Chelonian arrangement in which each arch stands on two centra. The loss of a definite tuberculum on the dorsal ribs is suggestive of the complete loss of that articulation in Chelonia.

The development of a short, powerful ulnar crest on the humerus and the slight upturning of its head are also resemblances to the same group.

In fact, although our knowledge of *Eunotosaurus* is too small to admit of a definite statement to that effect, it is by no means improbable that it is an actual ancestor of the Chelonia. Whether it be or not it does, I think, give us a great many suggestions of the changes which must have taken place during the development of the Chelonian shell and all that it implies.

I have to thank Drs. A. Smith Woodward and C. W. Andrews for their kindness to me during my work at the Natural History Museum, and Dr. L. Péringuey for permission to examine the South African Museum specimen of *Eunotosaurus*. The Rev. J. H. Whaits was the finder of R. 4054, the best existing specimen of this rare type.

Finally, my discussion of "Archichelone" owes much to the well-known work of many authors, amongst whom Drs. L. Dollo, O. P. Hay, W. R. Weiland, and J. Versluys are specially noticeable. When discussing so complex a subject as Chelonian ancestry it is impossible, if the result is to be at all clear, to attribute each part to its original author, a fact which must be my excuse for not acknowledging my indebtedness in detail.

#### EXPLANATION OF PLATE VII.

##### *Eunotosaurus africanus* Seeley.

- Fig. 1. Dorsal view of specimen No. 49423. *L.S.*, lateral scute; *M.S.*, median scute.  
 2. Ventral view of same. *Cl.*, clavicle; *Cor.*, coracoid; *H.*, impression of humerus; *I.Cl.*, interclavicle; *Sc.*, scapula.  
 3. Lateral view of specimen No. R. 4054. *Il.*, ilium; *Sc.*, scapula; I-IX., ribs.  
 4. Oblique dorsal view of same; I-X., ribs.

All the figures rather less than natural size.

54. Notes on some Carnivorous Therapsids. By D. M. S. WATSON, M.Sc., F.Z.S., Lecturer on Vertebrate Palæontology in University College, London.

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(Text-figures 1-7.)

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During the last ten years a very large number of perfectly distinct genera and species of Carnivorous Therapsids from S. Africa have been described, but of the vast majority of these we know only the dentition or at most the outside of the skull.

This paper is intended to indicate the very great differences which may occur in these types, and to show how caution is necessary in extending any morphological fact discovered in any form even to its apparently close relatives.

## BAURIA CYNOPS Broom. (Text-fig. 1.)

During my visit to S. Africa I collected from the *Cynognathus* zone of Essex, Dist. Albert, a small "Cynodont" skull; which, when I found it, was very much weathered and broken into innumerable pieces. These fit together and give us a nearly complete but somewhat crushed skull, which is curiously preserved, the bones being very well preserved in some parts and completely weathered away in others. The dentition is perfectly preserved.

The skull is considerably smaller than that of the type-specimen of *Bauria cynops*, but direct comparison with a cast of that example and with Dr. Broom's figures of it, shows no features in which they differ.

The incisors are large and not of circular section; they are bluntly pointed, and there is a worn face on the posterior surface of each, so that they are sub-scalpriform.

The canine is nearly circular in section.

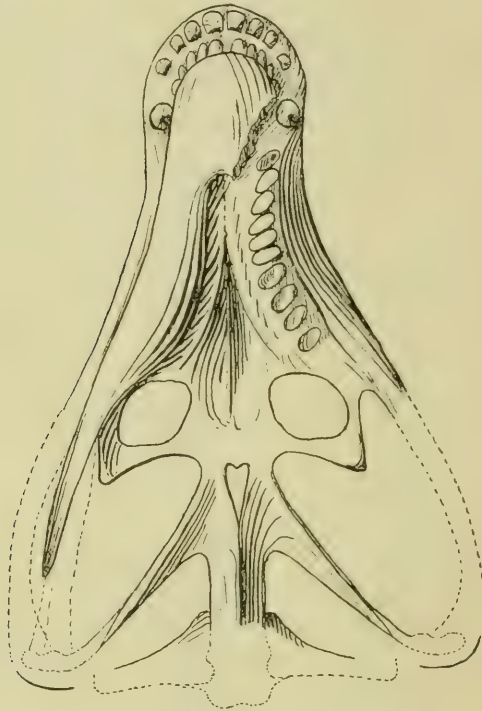
There are ten cheek-teeth visible in the upper jaw, of which the well-preserved crowns of the first and last four are preserved. They show no trace of cusps, but are ground down smooth in such a manner as to suggest a rodent-like movement of the jaw. There is a short diastema before and behind the canine.

The lower dentition is not so well known; the lower incisors are not markedly flattened anteriorly, and do not show clear

wear-facettes on their anterior faces corresponding to those which they undoubtedly made on the upper teeth. They are succeeded at once by the canines.

The lower cheek-teeth are slightly narrower from side to side than the upper teeth, and are convex, grinding on the concave upper crowns.

Text-figure 1.



*Bauria cynops* Broom.

Restoration of palate, from a specimen collected by the author at Essex,  
Dist. Albert, C.P.  $\times 1$ .

The palate is quite well shown in the specimen, but in some regions only in impression.

There is a secondary palate, which, however, does not extend nearly so far back as in *Diademodon*, and of which the posterior borders meet in a very acute angle (*i. e.* it has only just closed up). The posterior nares are divided by a septum, presumably formed by a median vomer. Posteriorly the roof of the narial passage slopes down very rapidly. Just behind the last maxillary tooth on each side the palate is pierced by a large suborbital fossa,

bounded on the outside by a narrow bar which is certainly transpalatine. The *pterygoid* no doubt combines with this bone to form the relatively small flange against the inner side of the lower jaw. Behind this region the two bones are separated by a small interpterygoid vacuity, which is shown quite conclusively to be undivided, no parasphenoid crossing it as is usually the case in early Therapsids.

The inner edge of the pterygoid, which forms the border of this vacuity, rises, when viewed from below, until it meets its fellow, and the two then end in suture with the very deep keel of the basisphenoid.

From the pterygoid at the side of the interpterygoid vacuity the posterior ramus runs off. It has a deep flange down its outer border and a horizontal ledge on the inner side. The pterygoid ramus of the quadrate runs along the front face of this bone as in all reptiles, whilst in the Cynognathids, in which the apparent posterior ramus of the pterygoid is really formed by the alisphenoid (=epipterygoid), it runs behind.

With the skull of *Bawria* described above are some very badly preserved postcranial bones. The scapula is fairly well preserved, and seems to show that the blade was narrow and had *no* spine and no definite acromion.

The coracoid and precoracoid are also shown; they are of the ordinary South-African Therapsid type, but are relatively very large. The whole arrangement must have closely resembled that figured by Dr. Broom in *Ictidosaurus*.

#### MICROGOMPHODON OLIGOCYNUS Seeley. (Text-fig. 2.)

Another Cynodont which must be regarded as a close ally of *Bawria* is *Microgomphodon oligocynus*, known only by the type-skull. [The fine skeletal fragment which Seeley referred to this genus is shown by the very unsatisfactory jaw fragment to be quite distinct, being, no doubt, a Cynognathid.]

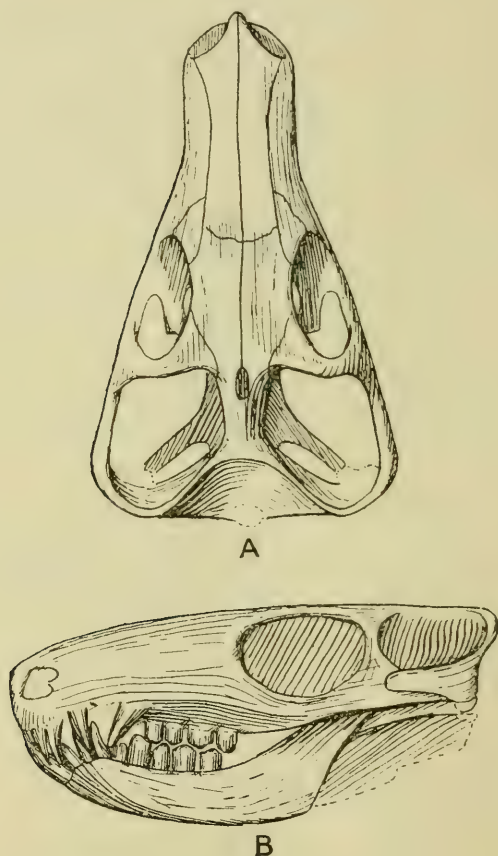
The type-skull is illustrated with slight restoration in text-fig. 2, which should be compared with Prof. Seeley's excellent lithographic figures (Phil. Trans. 1895, B, pl. i. figs. 1-4). The animal resembles *Bawria* in the following respects:—

1. The short temporal region.
2. The relatively heavy face.
3. The dentition.
4. The presence of an interpterygoid vacuity.
5. The presence of suborbital vacuities.
6. The slight reduction of the posterior part of the lower jaw.
7. Small squamosal.
8. The nostril directed more anteriorly than outward.
9. The nasal not widened posteriorly.
10. The frontal entering into the orbital margin.

The upper incisors are subscalpriform and worn, exactly as in

*Bauria*, and the very large and procumbent lower incisors are also very markedly chisel-shaped. There seems to be little doubt but that the wear of these teeth is similar to that of rodent incisors and that the front of the tooth was harder than the back, although the teeth seem to be enamel-covered all round.

Text-figure 2.



*Microgomphodon oligocynus.*  $\times 1$ .

A. Restoration of skull from the dorsal aspect. From Prof. Seeley's type-specimen.

B. Restoration of skull from the side.

A curious feature of this type, shared also but in a less marked degree by *Bauria*, is the very great space between the posterior ramus of the pterygoid and the paroccipital process.

## SESAMODON.

Another type which has to be brought in connection with *Bauria* is *Sesamodon*. This type is probably represented in the British Museum by the anterior part of a skull broken off through the middle of the orbits. Part of the dentition is fairly well preserved. The skull, so far as it goes, is of exactly the same size and proportions as the type, but differs markedly from Dr. Broom's restored figure in that the lower canine does not bite outside the maxilla but inside, in the usual way among Therapsids. As Dr. Broom's type-specimen is extremely weathered and badly preserved, it is quite possible that the part of the maxilla outside this tooth was removed by weathering.

In any case, judging only from Dr. Broom's figures of the type-specimen, the animal resembled *Bauria* in the following ways:—

1. Short temporal region.
2. The heavy face.
3. The general features of the dentition.
4. The small squamosal.
5. The feeble postorbital arch.
6. The frontal forming part of the orbital margin.
7. The nasal not widened posteriorly.
8. The prefrontal excluding the lachrymal from the nasal.
9. The interpterygoid vacuity, and the great distance between the posterior ramus of the pterygoid and the paroccipital process.

The group, which may be called the Bauridæ, including these three reptiles, differs from the Cynognathidæ (*Cynognathus*, *Dia-demodon*, and *Thirachodon*) and the Nythosauridæ in the following series of characters:—

1. The short temporal region.
- [2. The heavy face.]
3. The nostril directed more forward than outward.
4. The nasal not widened posteriorly.
5. The frontal forming part of the orbital margin.
6. The powerful incisors and grinding "molars."
7. The small squamosal.
8. The large septomaxillæ on the face.
9. The interpterygoid vacuity.
10. The suborbital vacuity.
11. The great distance between the posterior ramus of the pterygoid and the paroccipital process.
- 11*a*. The absence of the long narrow bar formed by the pterygoids and parasphenoid behind the region of the transpalatine.
12. The presence of a quadrate ramus of the pterygoid.
13. The posterior position of the notch in the angular and the large size of its reflected lamina.
14. The lack of an acromion and spine on the scapula.
15. The large coracoidal elements.

These characters are, of course, of very different values, but, taken together, do show that the Bauridæ differ enormously from the Cynognathidæ.

It may be argued with an appearance of truth that these characters are all merely primitive ones, and that the Bauridæ are derived from the same near "Cynodont" ancestor as the Cynognathids, but, although much specialised in some ways, are retarded in other features. This is in essence the view that Dr. Broom stated of *Bauria* in the form of a genealogical tree in December 1911, and which, I believe, he still holds.

I endeavour to show in the remainder of this paper that Dr. Broom's view is now untenable. The method I employ is to discuss, with the aid of a series of specimens, of which the relative ages are known, the evolution of certain selected features of the skull of a Cynognathid, and then endeavour to show that the conditions in the Bauridæ could not have been derived from those in any, except perhaps the earliest, of these stages.

The series of forms I shall use are:—

*Dimetrodon*; Upper Carboniferous? or Artinskian.

\**Arctops willistoni*, gen. et sp. n.; *Endothiodon* zone? Middle Permian? or earlier.

*Scymnognathus whaitsi*? Broom; *Endothiodon* zone. Middle Permian.

*Arctognathus curvimola* (Owen); *Cisticephalus* zone. Upper Permian.

*Diademodon*; *Cynognathus* zone. Middle Trias.

The first of these is a North-American Pelycosaur, and the last a South-African Cynognathid. The other three are South-African Gorgonopsids. It is certain that they are not actual ancestors of one another, but they may be as nearly related as the animals included in the early phylogenies of the horse.

Baur, Case, and v. Huene have published more or less complete accounts of the occiput of *Dimetrodon*, and I am indebted to the extreme kindness of Prof. S. W. Williston for the gift of a magnificent specimen which has been of the utmost use to me. *Dimetrodon* has a large, round occipital condyle, in front of which the thick basioccipital forms the narrow floor of the brain-cavity, and articulates at the sides with the exoccipitals and opisthotics, which are usually distinct. The opisthotics form powerful paroccipital processes lying below the small post-temporal fossæ. The small exoccipitals lie on the extreme posterior surface, projecting at the sides into processes which run outwards towards the post-temporal fossæ far above the bottom edge of the paroccipital processes. The whole bone looks as if it had only recently become a part of the skull, and was still only very imperfectly connected with the rest of the occiput. The foramen jugulare lies high up at the back of the skull between the lower

\* Founded on a skull in the G. G. Bain collection, B.M.N.H. R. 4099, from Howse's Port. It is distinguished by the extreme width of the parietal region and the small size of the orbit.

edge of the lateral process of the exoccipital, the opisthotic, and the basioccipital.

The front face of the paroccipital process is formed by the pro-otic, and its lower surface is channelled. The fenestra ovalis is a large, irregular hole, not bounded by bone in front, lying below the level of the base of the basioccipital condyle. The special process of the opisthotic which forms its posterior border has a wide, smooth face looking forwards and outwards, and is supported on the inner side by a corresponding process from the basioccipital.

The basisphenoid, as shown by Case's figures, has large tubera reaching back towards the fenestra ovalis, and powerful basiptyergoid processes of a more or less ordinary character.

The basicranial and otic region of the very primitive Gorgonopsid *Arctops* closely resembles that of *Dimetrodon*. It has a large, round basioccipital condyle and a thick basioccipital which supports the exoccipitals and opisthotics. The paroccipital processes are very powerful, lying below the small post-temporal fossæ. The exoccipitals are extremely similar to those of *Dimetrodon*, lying on each side of the foramen magnum and sending a special process out towards the post-temporal fossæ. The exoccipital even in this type is only incompletely included in the occiput. The foramen jugulare is high up on the back of the skull.

The front face of the paroccipital process is formed by the pro-otic, and its lower border and front face are channelled by a groove at the inner end of which lies the large and rather irregular fenestra ovalis. This is placed at about the level of the lower surface of the basioccipital condyle, and is completely enclosed by bone.

The basisphenoid forms two very large tubera, between which is a deep depression terminated abruptly in front by the junction of ridges from the tubera to form a very deep median keel continuous with the parasphenoid.

The tubera basisphenoidalia are far back, and end in a ridge just in front of the fenestra ovalis.

The basiptyergoid processes are curious horizontal plates standing out from the sides of the flat, vertical plate which forms the whole anterior part of the basis cranii.

*Seymnognathus whaitsi*\* differs far more from *Arctops* than the latter does from *Dimetrodon* in this region.

The basioccipital condyle is no longer round, but forms a mere lip round the lower border of the foramen magnum. The whole arrangement is so remarkable that if I had not myself removed the thin skin of matrix surrounding it, I should not have believed it possible. This lip is no doubt partly formed by the exoccipital, as it extends up round the sides of the foramen magnum.

\* This is the specimen the lower jaw of which I described under the name *Seymnosuchus whaitsi*, Ann. & Mag. Nat. Hist. ser. 3, vol. x. p. 578, fig. 3. I am not certain of the identification.

The basioccipital is a very thin bone, articulating as usual with the exoccipitals and opisthotics.

The exoccipital is an exactly similar bone to that of *Arctops*. The paroccipital process is very shallow, so that the foramen jugulare lies much nearer the bottom of the skull, and actually looks as much downward as backward. The front face of the paroccipital process is slightly channelled, and the fenestra ovalis lies at the inner end of this groove above the level of the basioccipital condyle. It is a comparatively small hole surrounded by a smooth and badly-preserved area of bone.

The tubera are much lower and much further forward than in *Arctops*, the lower surface of the basisphenoid being only comparatively slightly depressed.

The basipterygoid process is very similar to that of *Arctops*, but seems to be pierced by a canalis Vidii.

It is at once obvious that most of the differences between this type and *Arctops* are due to a reduction in depth of everything which lies below the bottom of the foramen magnum.

The type and only existing skull of *Arctognathus* is unfortunately damaged so that nothing behind the fenestra ovalis is visible. In this form the basioccipital is even thinner than in *Scymnognathus*, and the fenestra ovalis lies above the bottom of the foramen magnum. The tubera basisphenoidalia are represented only by the thickened margins of the slightly concave triangular lower surface. The basipterygoid process is similar to that in *Scymnognathus*, but is relatively further forward.

In *Diademodon* the basioccipital is so thinned that the centre part of the thin lip-like condyle of *Scymnognathus* is pinched out altogether, leaving the two condyles, which are no doubt mainly exoccipital. Although no definite suture has ever been seen, the texture of the bone makes it certain that the exoccipital in *Diademodon* is a small triangular bone forming the lower margin on the extreme back of the skull. The fenestra jugularis lies entirely on the lower surface and does not face in the least backward. The paroccipital process is more massive than in *Scymnognathus* owing to the fact that the post-temporal fossæ lie above the level of the foramen magnum. The front face is channelled, and the fenestra ovalis lies at the inner end of the groove considerably above the lower margin of the foramen magnum.

The tubera basisphenoidalia are very reduced, being merely the thick edges of the nearly flat ventral surface of the triangular basisphenoid.

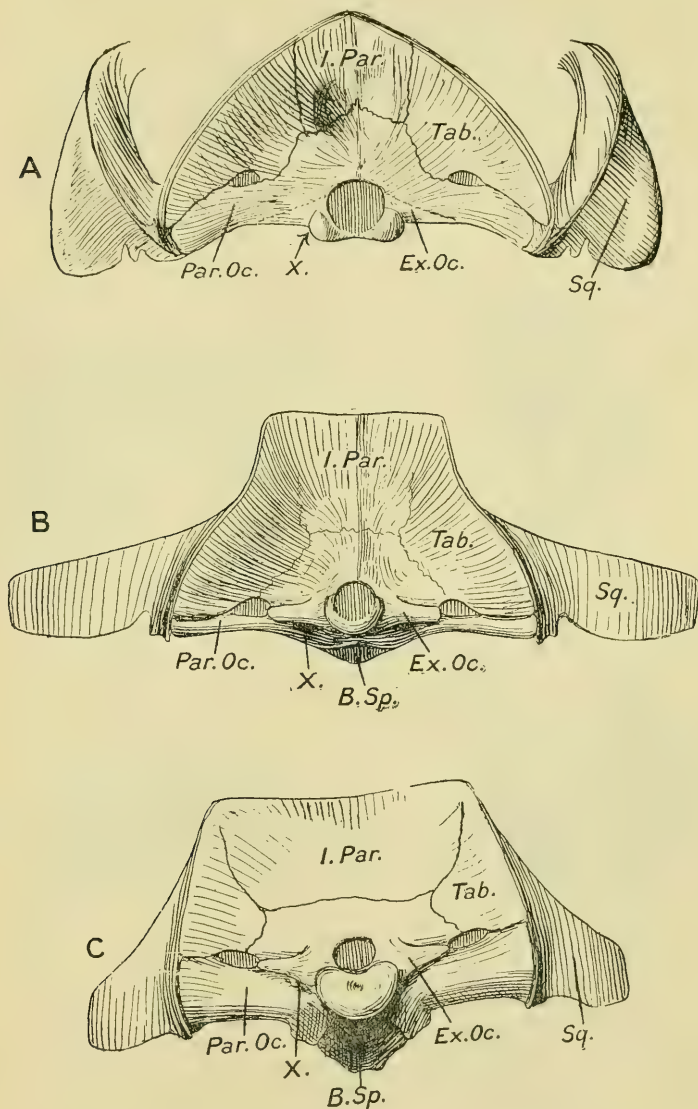
The horizontal basipterygoid process is similar to that of *Scymnognathus*, but much further forward.

*Arctognathus* is in all visible features of this region exactly intermediate between *Scymnognathus* and *Diademodon*.

Comparison of these descriptions with text-figs. 3 and 4 will show that the changes take place quite regularly with time, and that all of them depend eventually on the reduction of the whole regions which lie below the base of the brain, a reduction

which is shown extremely clearly in the three drawings of text-fig. 3.

Text-figure 3.



Occipital views of the skulls of:—

A. *Diademodon*.

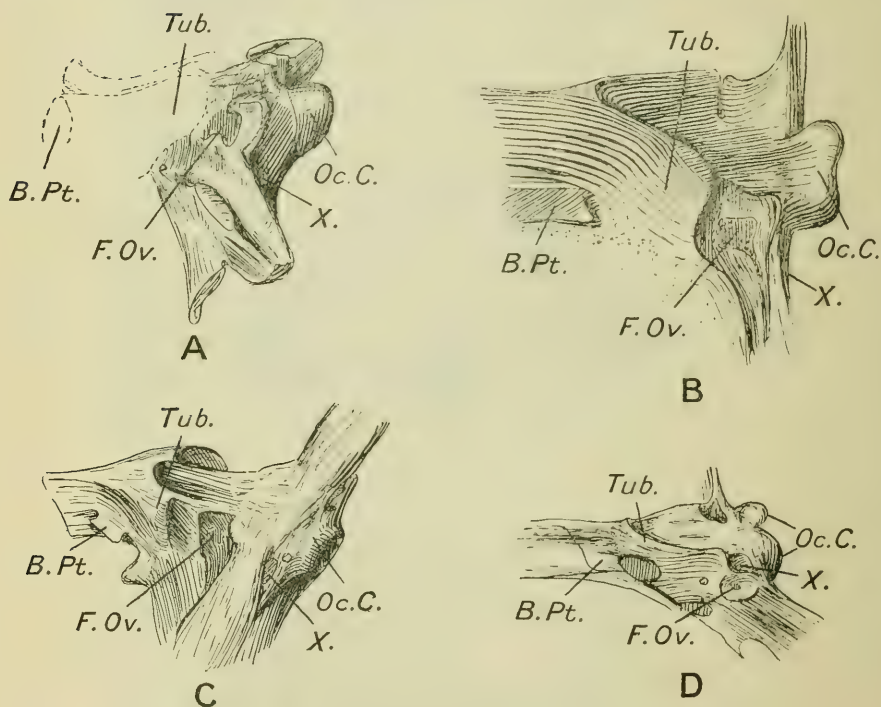
B. *Scymnognathus whaitsi*?

C. *Arctops willistoni*, gen. et sp. n.

*Par.Oc.*, Paroccipital process; *X.*, Foramen jugulare; *Ex.Oc.*, Exoccipital;  
*Sq.*, Squamosal; *Tab.*, Tabulare; *I.Par.*, Interparietal; *B.Sp.*, Basisphenoid.

Now, according to Dr. Broom's figure of the occiput of the type-skull of *Bauria*, the basioccipital condyle is large and rounded, much more like that of *Arctops* than any other of the series described above. The fenestra lies far above the bottom of the occiput, looking directly backwards. There is no trace of the gradually developed triangular lower surface of the basisphenoid which is so characteristic a feature in Cynognathids. In fact, it seems quite certain that the basicranial region of *Bauria* is the product of an utterly different type of change from that which has led to that of *Diademodon*, and as the features of

Text-figure 4.



The occipital and otic regions of :—

- A. *Dimetrodon*.
- B. *Arctops willistoni*.
- C. *Scymnognathus whaitsi*?
- D. *Diademodon*.

Viewed from below and the right side.

*Tub.*, Tuberosities of basisphenoid; *Oc.C.*, Occipital condyle; *X.*, Foramen jugulare;  
*B.Pt.*, Basipterygoid process; *F.Ov.*, Fenestra ovalis,

this region in the *Endothiodon*-zone Gorgonopsid *Scymnognathus* are obviously prophetic of those of Cynognathids, it will follow that the Bauridæ have had a quite different ancestry since that time, which is long anterior to the development of a "Cynodont" structure—i. e., a secondary palate in any form.

This conclusion, if true, will necessitate the splitting up of the Order "Cynodontia," and the recognition that it includes at least two distinct branches which were separate when they independently acquired a secondary palate.

The detailed structure of the palate of any Gorgonopsid is not known beyond the possibility of doubt.

All Gorgonopsids which I have seen agree in the following features:—

1st. There is a long region in front of the basisphenoid in which the two pterygoids are in contact, apparently with a median parasphenoid, but perhaps for part of the distance with each other, and in which their lateral margins are parallel; so that the whole forms a narrow bar behind the powerful descending processes of the pterygoids.

2nd. If an interpterygoid vacuity is present it is very small, and lies just between the descending flanges of the pterygoids.

3rd. There is a deep groove down the middle of the posterior part of the palate.

4th. There are no suborbital vacuities.

5th. There are very large posterior nares, which are separated by a bar lying considerably above the level of the lower edges of the maxillæ, which tend to be approximated.

No skull I have seen shows all the sutures on the palate satisfactorily. The skull of *Arctops* shows many of them, but most unfortunately, owing to its having been split longitudinally, those in the middle are not clearly visible posteriorly.

The type-skull of *Gorgonops* shows many sutures in a rather indefinite manner.

As Dr. Broom has pointed out, the bar which divides the posterior nares in *Gorgonops* and many other forms is actually single. It has to be considered whether, like the single "vomer" of the Anomodonts, it is really composed of a pair of fused prevomers, or whether it is a parasphenoid. Its complete resemblance in shape, even to the grooves on its upper surface for Jacobson's organs, to the undoubted prevomers of many Therocephalia, suggests that it is to be interpreted in the same way; and in the type-skull of *Arctops* it actually seems to be double when seen in section on the anterior end of the specimen, about one centimetre in front of the posterior end of the posterior nares. In this specimen, in place of the single dorsal ridge which occurs in *Scymnognathus*, there are two less than a millimetre apart, and the groove between them seems to be continued by a suture into the palate. If this observation is correct, and the condition of the specimen in this region is not good enough for certainty, then there can be no doubt that the bar between the palato-nares in

*Gorgonops* is really composed of a pair of prevomers fused, just as is the rather similar bone in the *Anomodonts*.

In the type-specimen of *Gorgonops* it seems clear that there is no median suture down the palate between the posterior nares and the very small interpterygoid vacuity. On the other hand, there seems to be very indefinite sutures along the side walls of the median groove of the palate, exactly in the position where the sutures between the vomer and palatines and pterygoids lie in *Diademodon*.

If this be so then *Gorgonops* will have a large mammalian vomer in the posterior part of its palate and a fused pair of prevomers anteriorly.

In *Arctops*, which is much more primitive than *Gorgonops*, there is some evidence suggesting that the pterygoids reached forward to the prevomers.

Comparison of the series of characters recorded above as features of the Gorgonopsid palate with the similar series on p. 1022 of this paper referring to *Bauria*, will show that *Bauria* differs in its palate in exactly the same manner from *Gorgonops* as it does from *Diademodon*.

In fact the Gorgonopsid palate, as I have previously pointed out, presents a very close resemblance to that of the Cynognathids, a resemblance which is much more striking in the advanced *Arctognathus* than in the more primitive *Gorgonops*.

If the interpretation of the structure of the palate of *Gorgonops* given above be correct, then the only differences between it and that of a Cynognathid are the development of a secondary palate, the beginnings of which are seen in that type, and the concurrent reduction of the prevomers; a change which is paralleled in Crocodiles.

Amongst the other characters, of which a progressive and orthogenetic change is seen in this series of skulls, are the occiput and the temporal region.

The occiput of *Arctops* (text-fig. 3 C) is very nearly flat, with a minute foramen magnum and only very slight projecting ridges formed by the tabulares and squamosals. It only differs from that of the Deinocephalian *Titanosuchus* in the slightly greater spread of the squamosals. In particular, it resembles this animal in the very great breadth of the interparietal.

In *Scymnognathus* (text-fig. 3 B) the occiput is deeply concave and the squamosals very wide. The interparietal is very much narrower than in *Arctops*.

In *Diademodon* (text-fig. 3 A) the occiput is very concave and the interparietal narrow. This form, however, differs pronouncedly from the Gorgonopsids in its very largely developed squamosals, a feature not shown in the Nythosaurians which seem to be related to it.

In the temporal region *Arctops* is remarkable amongst Gorgonopsids for the extraordinary width of the parietal region and the

shortness of the temporal fossæ, which are only about half as long as the width of the parietal bone.

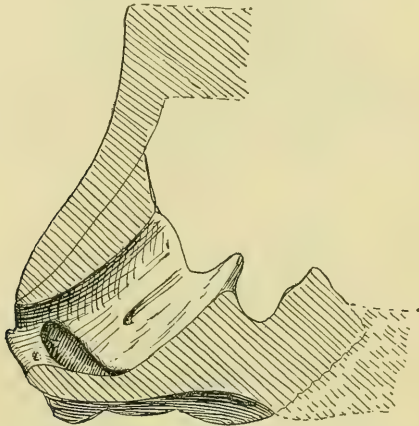
In *Scymnognathus* the parietal region is much narrower, and the temporal fossæ nearly as long as the parietal region between them is wide.

In *Arctognathus* the temporal fossæ are longer than the parietal region is wide, and in the Cynognathids they are very long, and the parietals form a narrow crest.

*Brain-cavity of Scymnognathus.*

The specimen of "*Scymnognathus*" shows the brain-cavity, although, owing to the hardness of the matrix with which it was filled, this is not very well preserved. Its main features are, however, quite certain, but it does not merit a lengthy description. The general structure will be best understood from text-fig. 5.

Text-figure 5.



The brain-cavity of *Scymnognathus whaitsi*? in sagittal section.  $\times 1$ .

There is a distinct resemblance to *Diademodon* owing to the comparatively thin basioccipital and the large opening to the vestibule through the posterior end of which the tenth nerve had its exit. The general features of the vestibule recall *Diademodon*, but there is no visible trace of a cochlea.

The chief differences from the more recent animal are that the whole cavity for the cerebellum is very much smaller, and that its base rises very rapidly in front, very much as it does in *Dimetrodon*.

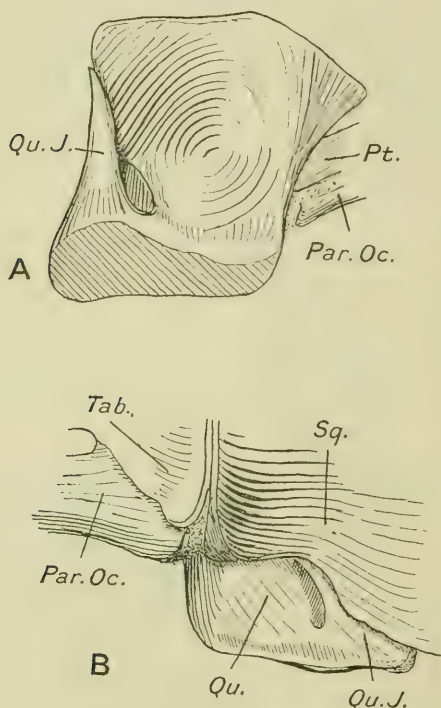
The prootic, although it extends further forward than in the Anomodonts and *Dimetrodon*, has more of the greater anterior

projection which, occurring in *Diademodon* and also in *Ornithorhynchus*, has a long suture with the parietal.

*Quadrate region of Gorgonopsids.*

A large Gorgonopsid skull, at a slightly more advanced stage of evolution than *Arctops*, from the *Endothiodon* zone of Beaufort West, which was collected by the Rev. J. H. Whaits and is now in the British Museum, shows the quadrate and the bones surrounding it in a most perfect manner.

Text-figure 6.



The quadrate and surrounding bones of a Gorgonopsid from the *Endothiodon* zone of Beaufort West.  $\times 1$ .

A, from in front; B, from behind.

*Par.Oc.*, Paroccipital process; *Pt.*, Pterygoid; *Qu.*, Quadrate; *Qu.J.*, Quadratojugal; *Sq.*, Squamosal; *Tab.*, Tabulare.

The squamosal has a powerful articulation with the end of the paroccipital process; the bone there sends a process dorsally and medially which articulates with the tabulare, postorbital, and

probably the supraoccipital and parietal. Lateral to its articulation with the paroccipital process the squamosal is very massive, and after passing directly outward for some distance finally curves round and forms part of the zygomatic arch. The front face of the lateral part of the squamosal is excavated for the quadrate and quadratojugal.

The quadrate is a comparatively large bone with a trace of the pterygoid ramus in a slightly turned back area behind which the posterior end of the pterygoid passes. The lower margin of the bone is thickened to form the condyle, which, although its surface is destroyed, must have looked very much more forward than downward.

The quadratojugal is a small bone completely fused with the quadrate at the lower margin and actually forming a good deal of the condyle. On the posterior surface it is seen to overlap the quadrate; separating a good deal of its posterior surface from the squamosal between the two bones is a large foramen.

In *Arctognathus* the quadrate is partially shown on one side, and relatively is considerably smaller than that of the earlier type described above.

In *Diademodon* the quadrate as it has been described by Seeley, Broom, and myself, is very much smaller. It will be remembered that it is possible that there is a foramen through the quadrate of *Diademodon* suggesting that even in that form there is a rudimentary and otherwise totally fused quadratojugal.

### *The Palate of Lycosuchus?*

In the British Museum there is a very large "Therocephalian" skull (R. 4100) from Vit. Kyk. Gouph, collected by T. Bain from the *Tapinocephalus* zone.

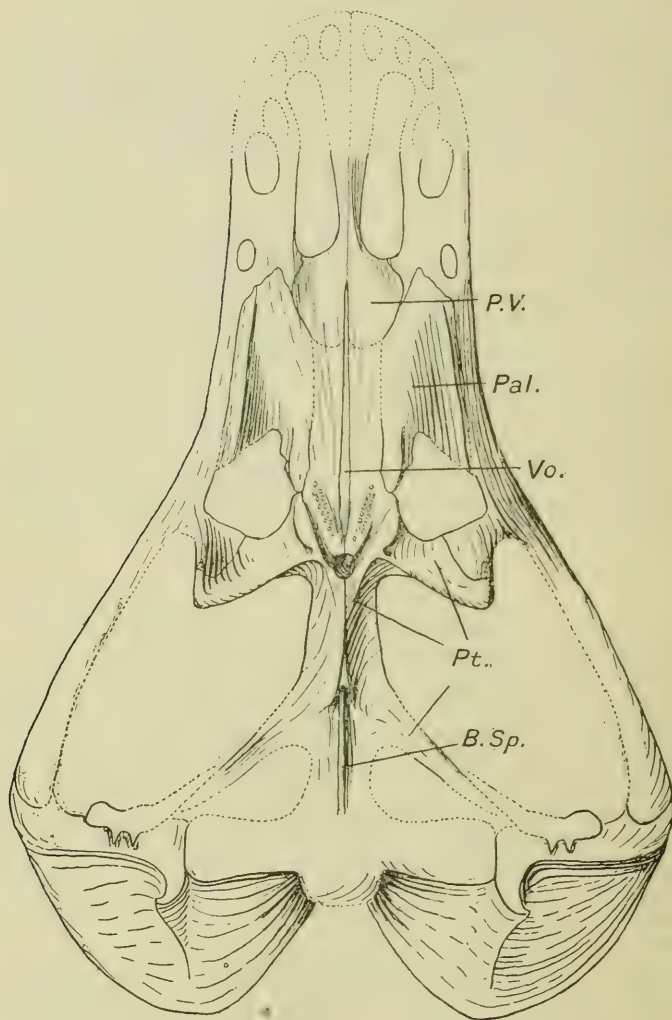
This is perhaps not definitely determinable, as it is broken off through the canine, behind which it shows only one molar tooth. I can see no generic differences, in fact few differences, except that it is considerably larger, from the specimen of *Lycosuchus vanderriti* described by Dr. Broom. In any case it is unquestionable that it is closely allied to *Scylacosaurus*. The palate of this individual is very well but curiously preserved, having been cleaned by the weathering of a broken face which passes along the palate, having its medial portion adherent to one block and the remainder to another.

The basisphenoid is not completely shown, but has a very deep (2 cm.) and narrow keel along its ventral surface. Although they are only incompletely exposed, it is evident that the basi-ptyergoid processes are the usual flat plates found in all South African "Carnivorous" Therapsids. It is clearly shown that the epiptyergoid, which is a comparatively narrow but laterally flattened bone, articulates with the process.

The pterygoid is the usual large triradiate bone; it articulates with the basiptyergoid process and sends a ramus back to pass

behind the quadrate. The ramus has a ridge down its outer margin and a flat shelf on the inner side.

Text-figure 7.



Restoration of the palate of *Lycosuchus*?  $\times \frac{1}{2}$ .

*B.Sp.*, Basisphenoid; *P.V.*, Prevomer; *Pal.*, Palatine; *Pt.*, Pterygoid;  
*Vo.*, Vomer.

In front of the basisphenoid the pterygoid rises into a high ridge overlapping on to the basisphenoidal keel, which terminates

suddenly, leaving the ridge on the pterygoid to form the side of a narrow interpterygoid vacuity; further forward the flange of the pterygoid meets its fellow of the opposite side, and the two run on in contact till they are again separated by a small round interpterygoid vacuity.

At the side of this region the process which combines with the transverse bone to form the powerful pterygoid flange is given off.

Further forward the bone bears a ridge with two irregular rows of teeth, and finally undoubtedly continues forward to the prevomer.

On the block from which the median part of the palate has been split away, there is very clearly shown a long median bone forming a narrow vertical plate. That this bone is not, as it might conceivably have been, formed by a fused pair of ridges on the dorsal surface of the pterygoids, is shown by the occurrence of very fine but I think definite sutures, between its posterior end and the pterygoids, and conclusively by the fact that what is undoubtedly a part of the pterygoid is applied to its lateral face ending in front in a very obvious manner. This median bone is clearly seen to pass between the posterior ends of the prevomers in front.

There can be no doubt but that this bone is the same as the vomer of *Diademodon*, and is the median bone in the same position which, if I am right, occurs in *Gorgonops*.

The palatine is a large bone with a long suture with the maxilla; posteriorly it forms the front border of the large sub-orbital fossa and its inner edge has a suture with the pterygoid, finally it has a short contact with the prevomer.

The two prevomers are very clearly seen in the specimen; posteriorly they are separated by the vomer, but in front they are in contact; the lower surface of the bar between the posterior nares, which is formed by them, has exactly the same form as that of the similar bar (which in my view is probably formed by a pair of fused prevomers) in *Gorgonops*.

The palate just described differs from that of *Scylacosaurus* only in the presence of the very narrow vomer.

This palate will be seen to resemble that of *Bauria* in very many features; in fact it differs from the palate of the nearly contemporary *Gorgonops* in exactly the same features that the palate of *Bauria* differs from that of a *Cynognathid*.

This specimen is the first that has shown a definite median vomer and a pair of paired prevomers in the same animal. It seems to me to add a very strong argument in favour of Dr. Broom's view that the mammalian vomer is not homologous with the "vomers" of a Lizard.

The various new facts brought forward in this paper show that the accepted division of the "Carnivorous" Therapsids into Therocephalia, *Gorgonopsia*, and *Cynodontia*, is far from satisfactory. In my opinion the differences between *Bauria* and its

allies and the Cynognathidæ are important—are, in fact, to a great degree actually the same as those separating the “Therocephalia” and “Gorgonopsia.” I do not regard these differences as being of ordinal value, and as a purely temporary measure propose to revive Owen’s term of Theriodontia as an Order, including in it as suborders the Therocephalia, with *Scylacosaurus* and *Lycosaurus* as well-known types; the Gorgonopsia, with *Gorgonops*, *Arctops*, *Scymnognathus*, *Arctognathus*; the Bauridæ, with *Bauria*, *Microgomphodon*, and *Sesamodon*; and the Cynodontia, to include the Nythosauridæ and Cynognathidæ.

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[Published December 1914.]

Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. By FRANK E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S., Prosector to the Society.

(Text-figures 1-9.)

XV. ON A NEW GENUS AND SPECIES OF THE  
FAMILY ACOLEIDÆ.

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| <i>Monacocestus erethizontis</i> , gen. et sp. n. .... | 1055 |

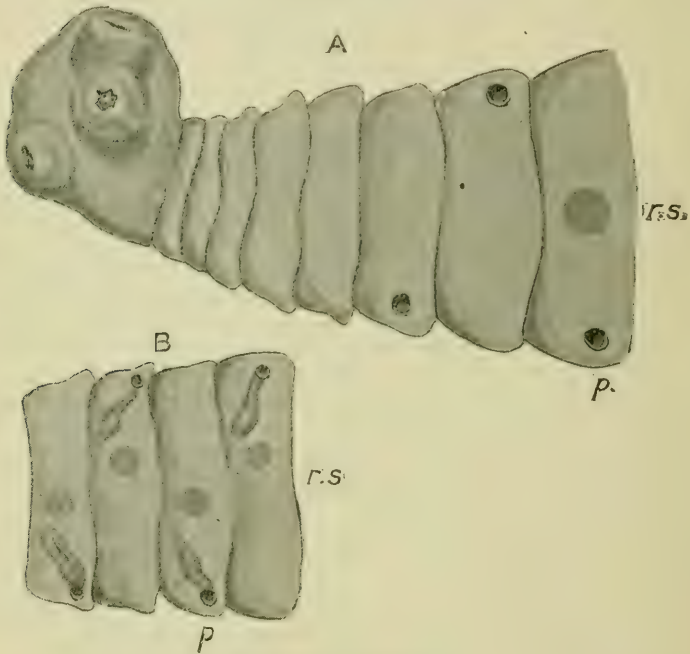
I obtained a large number of examples of this new Tapeworm from a specimen of the Canadian Tree-Porcupine, *Erethizon dorsatum*, which died in the Society's Gardens on May 14. From the comparatively short time which the host had lived in the Gardens (one year and two months) it would seem to be very possible that it was infected with the parasite before arriving in London, and that this Cestode is therefore an American and not a European genus or species. On the other hand, there are no facts which would render the opposite view untenable. But little is known of the longevity of these worms in their final hosts. To the naked eye, or after an inspection with a hand-lens, there is nothing remarkable in the worm, which, however, shows on a more profound anatomical examination to present several features of interest, of which the most important is the great reduction of the female efferent organs. This feature would seem to place it in the family Acoleidæ; but the systematic position will be considered after the structure has been gone into.

This species is medium sized, the examples reaching a length of 50 to 60 mm., or perhaps a trifle more; the greatest breadth is not more than just over 3 mm. When alive, the scolex end of the worm swayed about with considerable vivacity, which I have not observed to be generally the case among tapeworms, the movements being, as a rule, slower.

The segments are flat and thin, and at the end of the body get to be rather translucent. This lack of the usual white appearance is not, however, due to sterility; the very last segment in such examples as I examined, by means of sections, was gravid. The *scolex* is very distinct, though the body widens immediately after it. There are no hooks of any kind upon either the rostellum or the suckers. There is, in fact, no rostellum; the suckers are fairly large and conspicuous. Under examination with a lens, the neck appeared to be quite absent and the segmentation to commence at once. There is, however, as may be seen in longitudinal sections, a very short neck where no segments

are to be observed. In the strobila region the segments are at first very narrow; but they increase in length posteriorly, though never reaching a greater length than diameter. The hinder margins on either side project in the more mature segments over the following segment. The last segment of the body was often to be seen; it was narrower and a trifle longer than those immediately preceding it and somewhat oval in form. As already remarked, this segment did not prove to be sterile.

Text-figure 1.

*Monæcocestus erethizontis.*

A. General view of scolex and anterior proglottids.

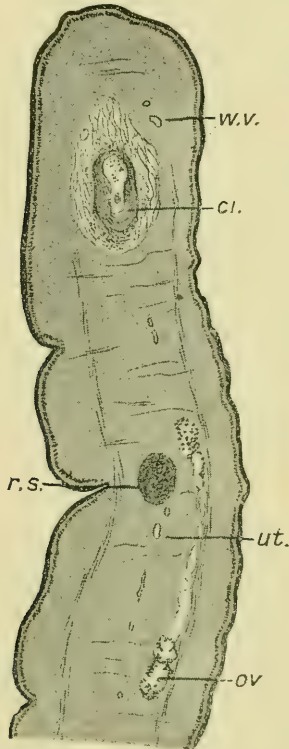
B. A few anterior proglottids, illustrating relative positions of receptaculum seminis and cirrus-sac.

p. Genital pore. r.s. Receptaculum seminis.

The *genital pores* alternate with rigid regularity from side to side of the body. The cirrus was frequently seen to be protruded, and very often an oval body bearing the cirrus also projected from the side; on making sections this body proved not to be the protruded cirrus-sac as might have been anticipated, but that sac surrounded by a certain part of the medullary tissue which together formed a marked bulge upon the side of the segment.

These are the only external characters to be noticed in this worm, whose identity or systematic position, as is obvious, could not be thereby determined. The flatness and thinness of the strobila is emphasised by transverse sections. In such, the fact may be observed that the cortex is of less diameter than the medulla. As is usual, the two layers of parenchyma are separated by a layer of transverse muscles, which is, in the present species,

Text-figure 2.

*Monæcocestus erethizontis.*

Part of a transverse section through a ripe proglottid.

*ci.* Cirrus-sac. *ov.* Ovary. *r.s.* Receptaculum seminis. *ut.* Uterus.  
*w.v.* Water-vascular vessels.

a thin one. So, too, are the longitudinal muscles, which are nowhere massed into bundles. They lie singly, but in several rows; nor is their arrangement regular. Thus the muscular system is altogether slight, and contrasts in this with various members of the family Acoleidæ. The muscular fibres themselves are slender,

and it is not a little unusual to find that the abundant dorso-ventral fibres are of stouter build, and thus much more conspicuous in a transverse section. Calcareous bodies are numerous in this species, and are to be found throughout the body both in the cortex and the medulla.

The *water-vascular system* consists of the usual four longitudinal trunks, of which the ventral are connected by the usual transverse vessels in each segment. Both in transverse and horizontal sections it can be observed that the two trunks of each side of the body are placed as nearly as possible side by side. The outermost of the two vessels, however, is slightly to one side, that is to say, it is, being the dorsal vessel, slightly dorsal in position of the ventral tube. It is well known that the relative positions of the dorsal and ventral tubes when lying side by side differ, being in some species arranged precisely in the reverse fashion to others. In the present worm the dorsal vessel lies to the outside, as I presume from the fact that the outer vessel is not the one which is connected with its fellow by the transverse vessel in each segment, and from the fact that it is from time to time much narrower in calibre than the inner ventral vessel. Often, however, the two vessels are of the same size. The transverse tubes lie in the middle of the medulla, and at the end of the segment. The inner longitudinal vessel bends inwards to give off the transverse vessel, which thus forms a Y-like angle. I could discover no trace of any network connected with any of the main trunks. Such a network exists in the family Acoleidæ, and is referred to by Fuhrmann\* in *Shibleya inermis*.

#### *Genital Organs.*

A peculiarity of this species—which, however, it shares with a good many Cestodes—is the early development of the genital organs. It agrees, for instance, with *Schizotenia americana* (to accept v. Janicki's identification of Stiles's species†) in this feature, a point which must be borne in mind in comparing the two. I recognised in longitudinal horizontal sections considerable traces of the genitalia in the fourth segment, and I would not like to assert the absence of still more undifferentiated beginnings in an earlier segment. In the sixth segment the cirrus-sac was fairly developed and the sperm-duct obvious; and in the sixth segment I saw for the first time a perfectly clear circular external pore. This was seen in a specimen mounted entire in glycerine, and it agrees with another specimen which I examined by sections. There were pores in all the segments posterior to the sixth. I have already mentioned the absolute regularity of the alternation of the genital pores from right to left side. The earliest segment in which the genitalia appeared to be quite functional was the ninth, in which I observed the

\* Rev. Suisse Zool. xvi. 1908, p. 70.

† Proc. U.S. Nat. Mus. xix. 1897, p. 165.

receptaculum to be full of sperm. Neither the testes nor the ova were ripe so early in the body.

The *testes* lie posteriorly in the segment just in front of the transverse water-vascular vessel. They form a narrow band running right across each segment, but contained within the area bounded by the lateral water-vascular trunks.

It may be seen in transverse and horizontal sections that the testes are not more than two deep and are in three or four rows. There are about 60-70 in each segment. I regard the testes as dorsal in position, because when the outer and dorsal water-vascular trunk moves away from its lateral position with reference to the inner tube, it lies to the side corresponding to that on which lie the testes. They are therefore dorsal, and the ovary is ventral in position.

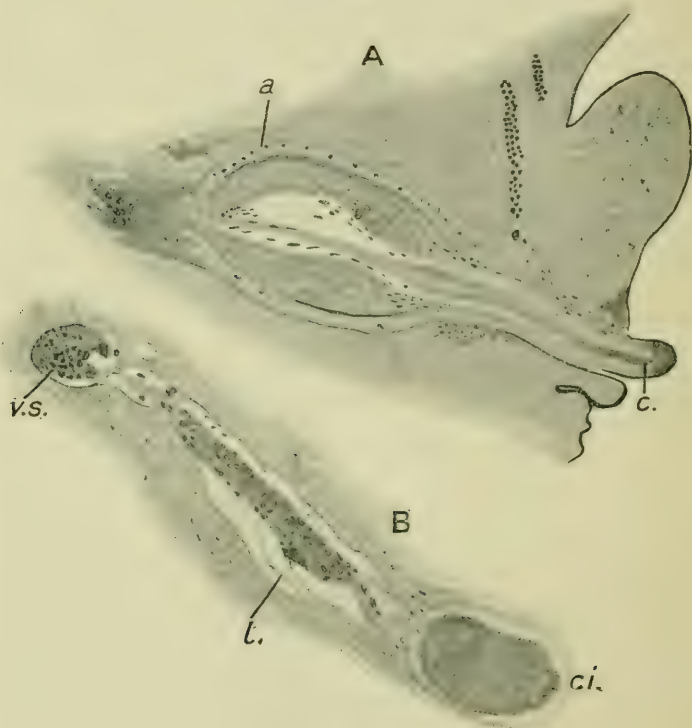
Furthermore, since the cirrus-sac passes to the same side of the two water-vascular tubes as that on which the testes lie, it has a dorsal position with regard to them; this point is not mentioned by Fuhrmann in his account of *Shipleya*. Moreover, as the transverse vessels arise from the ventral vessels they, too, are ventral in position, and therefore the female organs such as the receptaculum, which is more or less level with them, must be ventral. Fuhrmann states that in *Shipleya* the ovary is ventral. I have not been able to notice any ripe masses of spermatozoa in the testes, though there are many in the cirrus. This absence of sperm from the testes has already been noted by Fuhrmann in another genus.

The *vas deferens* of this worm is very remarkable. In the very young proglottids the vas deferens emerges from the cirrus-sac as a short and curved tube which is curved backwards towards the testes. In rather older proglottids the vas deferens is not much longer but is distinctly differentiated into two regions; there is a wider tube which emerges from the cirrus-sac and this abruptly becomes narrower in the distal region, where it ultimately breaks up into three or four branches for the supply of the testes. This differentiation of the vas deferens is much more highly developed in mature proglottids. The vas deferens after it emerges from the cirrus-sac runs forwards and inwards obliquely towards the anterior end of the segment, and that is away from the testes, which are posterior in position; this region of the vas deferens is that of the greater calibre, and the fine tube which issues from it is the sperm-duct proper and runs backwards towards the testes and thus at an acute angle with the anterior region. This is foreshadowed in the curved course of the entire vas deferens shown in the immature proglottids. To return to the anterior section of the vas deferens—this tube is very wide, relatively speaking, and often dilates at the ends, where it passes into the narrow section of the vas deferens, into a circular sac; its width varies in parts and according to the state of development of the segment.

The intimate structure of this region of the vas deferens is a

little difficult to make out. But it is clear that it forms a tube, slightly sinuous, which is walled by a layer of cells in which appear to lie masses of secretion, which masses are colloid in appearance and deeply stained by hæmatoxylin. They are found also within the tube, especially in its more dilated regions. These masses of secretion, as I suppose them to be, are shown

Text-figure 3.



*Monacocestus erethizontis.*

**A.** Cirrus-sac in longitudinal section.

*a.* Its cellular sheath. *c.* Slightly produced cirrus.

**B.** Proximal end of vas deferens.

*ci.* Cirrus-sac. *l.* Longitudinal muscular fibres. *v.s.* Dilatation of vas deferens.

in text-fig. 3. The tubular character of this dilated region of the vas deferens is very obvious in the younger proglottids, where the cells of the tube have not become modified by the secretion spoken of. In parts, for instance, in the terminal dilatation

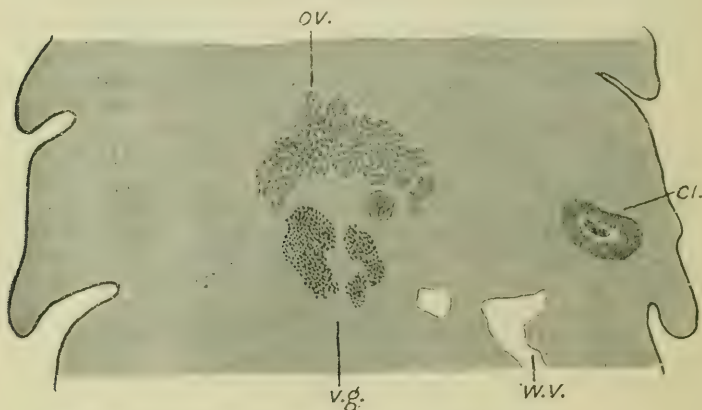
represented in text-fig. 3, the walls of the tube are thin but apparently still cellular. From this dilated extremity springs the fine and narrow distal region of the vas deferens, in which the actual walls are to be recognised with difficulty. These appearances suggest that we have to do here with an extremely exaggerated form of a vesicula seminalis, which possibly serves other purposes beside the mere storage of sperm; but as to what these functions are I have no reasons to form an opinion. It is, however, perhaps to be associated with the development of the sperm, which does not appear to come to maturity within the testes, as I have already pointed out. In all proglottids the dilated and glandular region of the vas deferens appeared to be full of sperm.

The *cirrus-sac* of this worm is large and reaches inwards across the two longitudinal tubes of the water-vascular system. It is perhaps half a millimetre in length. As already mentioned, the cirrus sacs alternate in position with absolute regularity in successive proglottids. Each cirrus-sac opens on to the exterior in mature segments rather behind the middle of the proglottid, and its position is oblique—the posterior end being directed anteriorly; the external aperture is thus directed rather backwards. I observed no individuals *in copula*, and it is difficult to understand how this takes place. In the case of other Acoleidæ, which are all, like the present genus, without female orifices in the mature segments, it has been suggested that the spiny cirri perforate the body. Of any such spines there seems to be no trace in the present species. But frequently the cirrus within the sac was dilated with masses of sperm, conspicuous on account of its deeply staining with hæmatoxylin. The cirrus-sac projects into a fairly deep genital cloaca which is, in the most anterior segments where the cirrus-sac is immature, quite as deep as the cirrus-sac is long. The distinctiveness of the genital cloaca is rather lost in the mature proglottids. The cirrus-sac itself is oval in form, with a gradually decreasing anterior region which projects into the genital cloaca. It is, in fact, pear-shaped with rather a long stalk.

When the cirrus-sac is quite fully formed, it is seen to lie in a rather specialised region of the body parenchyma. This region is formed of very lax tissue, which might thus be supposed to allow of greater freedom on the part of the cirrus-sac. Moreover, isolated but numerous muscular fibres run inside and outside of this lax area which are attached to the cirrus-sac and probably serve as retractors. This lax area is not limited to the region occupied by the cirrus-sac alone; it runs back and accompanies the first part of the sperm-duct. In a series of sections the cirrus-sac and the first part of the sperm-duct are seen to lie loosely in the lax tissue which extends beyond it in every direction. The cirrus-sac is extremely muscular, the walls being unusually thick. The muscle-layers are two, the outside being of fibres having a longitudinal direction, and within this is a

much thicker layer of circular fibres. The inner layer is twice, or in parts thrice, the thickness of the outer layer. The inner circular layer ceases with the diminution in diameter of the cirrus-sac on its way to the exterior; the inner oval region is alone thus fortified. The outer muscular layer, however, continues to the distal extremity of the cirrus-sac and its narrower projection. Outside of these muscle-layers the cirrus-sac is enclosed within a single layer of rather large vesicular cells with a prominent nucleus. It appeared to me that this layer was continuous with the epithelium of the ensuing vas deferens, though special to the cirrus-sac in its peculiar structure. The cirrus-sac, as usual among the Cestodes, contains delicate muscular fibres and nuclei within it in addition to the cirrus. In the younger stages in the development of the cirrus-sac the sac has

Text-figure 4.

*Monæcocestus erethizontis.*

A proglottid viewed in its entirety, to show the position and shape of the ovary (ov.) and vitelline gland (v.g.).

ci. Cirrus-sac. w.v. Water-vascular tube.

more delicate walls in the rounded part of it, while the region leading to the genital cloaca has thicker muscular walls; the precise reverse occurs in the adult sac. The *cirrus* itself lies in a perfectly straight line in the adult cirrus-sac, and is of even calibre throughout when not distended with sperm; there is nothing in the nature of a vesicula seminalis within the cirrus-sac such as has been described in many forms. But when charged with sperm, dilatations are formed locally which are therefore to be regarded merely as local turgescences due to the enclosed sperm, and not, as representing a definite dilatation on the course of the duct, such as is the receptaculum upon the course of the vagina in this and other tapeworms. In

the younger and more spherical cirrus-sacs of earlier segments the cirrus is coiled. It perforates the muscle-layers of the cirrus-sac to become continuous with the vas deferens without any change of diameter.

The *ovary* of this worm is ventral in position, as in *Shipleya inermis*. In horizontal sections it forms with the vitelline gland almost a complete ring, since the ovary is semicircular and the smaller vitelline gland serves to close the semicircle posteriorly. The ovary is larger than the vitelline gland, and lies, of course, more anteriorly in the segment. In transverse sections the ovary is seen to possess a longitudinal and tubular form, the greater part of the cavity being empty. This is illustrated in text-fig. 2 (p. 1041). It is there seen to be pressed closely against the transverse muscular layer bounding the medulla, and thus to lie below the receptaculum seminis and also, to some extent, the vitelline gland. The remarkable tubular form of the ovary in young proglottids might lead to its being confused with the commencing uterus, which, however, lies above it and on a level with the receptaculum ovarum. The ovary has thus a flattened form when viewed in its entirety. It is near to the middle of the proglottid verging towards the pore side. The young cells, which will become ova, are chiefly massed at the two ends right and left of the tubular ovary, and this region, as shown in the figure referred to, is somewhat dilated on both sides, forming an oval sac. The course of the tube when viewed in transverse sections is quite straight from side to side.

### § *Vagina*.

A careful inspection of the horizontal sections shows that, although no *vagina* opens into the so far isolated receptaculum seminis, the equivalent of a vagina would appear to be present. I cannot otherwise interpret a narrow straight duct which opens on to the exterior beside, and in front of, the cirrus-sac. This duct passes towards the interior of the body, up to a point on a level with the end of the outer half of the cirrus-sac; it is therefore of very limited extent. It ends at this spot in a dilatation, an oval sac. I have seen this tube ending blindly in a sac in four or five segments. There is thus no question of its normal presence; but I have seen it in the more anterior segments only, but which are nevertheless well provided with gonads, and a cirrus-sac as large as it is in the more posteriorly situated segments. The slender character of the duct and the delicate chamber into which it expands, remind me greatly of the conditions obtaining in my genus *Diplopylidium* \*. But in the latter worm

\* P. Z. S. 1913, p. 562. The illustration depicting the vagina of *Diplopylidium* (text-fig. 92, p. 563) may be compared with my description of the present species. In the text of that paper I have remarked that only in *Tetrabothrius* is this reversed position of pores. This is an obvious *lapsus calami* for *Tetradiscotyla*.

the small receptaculum passes posteriorly into a duct leading to the internal portion of the female apparatus. It seems to me to be impossible not to recognise in this tube a rudimentary vagina; but the dilatation can hardly be compared to a receptaculum, since that exists elsewhere.

In the first few proglottids of the worm, the female efferent apparatus is still more highly developed than in those proglottids which have just been considered. I find, in fact, in the first six or so of those proglottids in which the reproductive apparatus generally is recognisable in its details, that the vagina (text-fig. 5)

Text-figure 5.



*Monacocestus erethizontis.*

Part of a horizontal section through an anterior proglottid where the vagina (v.) has not commenced to disappear.

*g.c.* Genital cloaca.

is a wide thick-walled tube which opens on to the exterior close to, and in front of, the cirrus-sac on the one hand, and communicates with the receptaculum seminis on the other, thus forming a continuous female efferent apparatus, like that of more normal Cestodes. It is, perhaps, during this transient state that fertilization is effected, also in the normal way *viâ* this tube and not through the interstices of the body parenchyma. I have noted certain stages in the degeneration of the vagina; that part of it which opens into the receptaculum seminis persists, after it has

ceased to be a pervious duct, as a narrow tract of tissue blocked entirely by medullary parenchyma, but still retaining a definite wall (text-fig. 6) separating it from the surrounding parenchyma. As already mentioned, the external part of the duct persists longer as a pervious tube ending blindly and in a dilatation. This worm, therefore, is interesting as showing a transition between such a family as the Anoplocephalidae and the Acoleidae in point of its female efferent apparatus.

Text-figure 6.

*Monæcocestus erethizontis.*

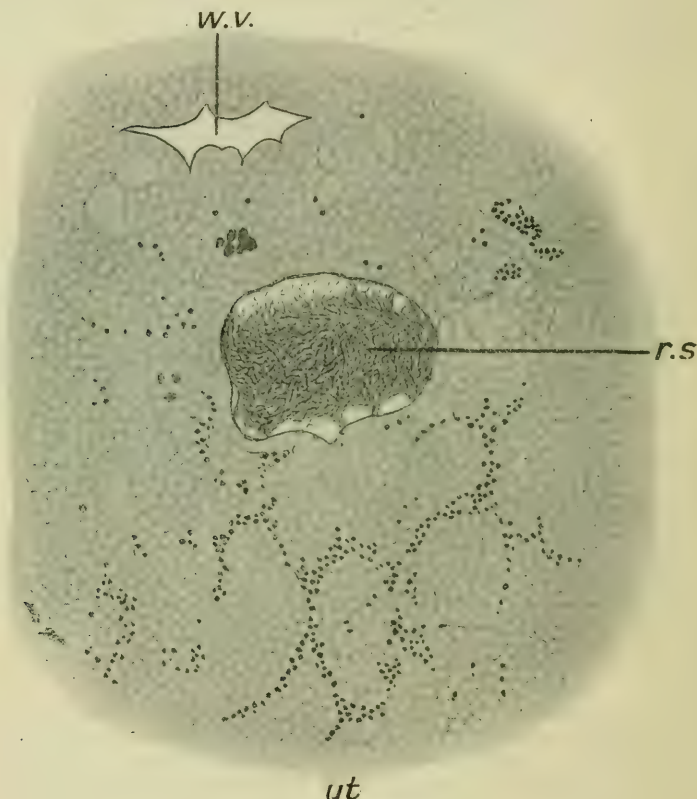
Part of a horizontal section through a proglottid a little further back than that referred to in text-fig. 5, to show degeneration of vagina (v.).

r.s. Receptaculum seminis. t. Testes.

The *uterus* of this worm is reticulate, except in very old proglottids in which a more complete fusion of the network tends to produce a saccular uterus. There are, however, even here, traces of the reticular condition. These may ultimately perhaps disappear. The uterus appears early in the body, and I have depicted it in young proglottids in text-figs. 7 & 8, which are respectively horizontal and transverse sections through young segments. A corresponding section (text-fig. 9) represents the mature uterus in subsequent segments. This organ is seen to lie quite medianly in the proglottid, that is to say, it is well above the ovary and in the same straight line with the receptaculum seminis. The ovary has disappeared in the more mature proglottids. The uterus at first forms a network of rather delicate strands which are abundantly nucleated but contain no lumen, or only a very narrow one. In transverse sections the lumen is quite visible in young proglottids, which are, however,

rather older than that depicted in text-fig. 8. The cavities appear in such a section to be detached, as the network is not so close as it becomes later. The cavities are lined with an epithelium which is at least less obvious in older uteri.

Text-figure 7.



*Monacoccestus erethizontis.*

Horizontal section illustrating the first appearance of the uterus (*ut.*).

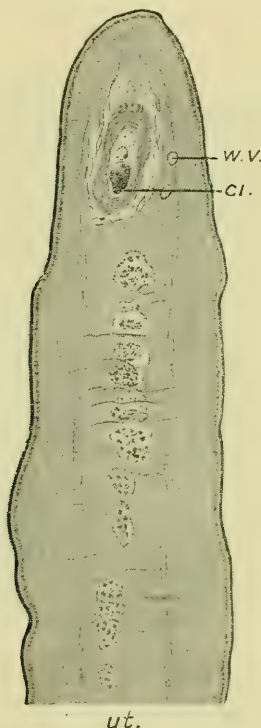
*r.s.* Receptaculum seminis. *w.v.* Water-vascular tube.

In all the sections referred to it may be seen that the uterus does not extend laterally beyond the trunks of the water-vascular system. The uterus is quite persistent, and is not replaced by anything of the nature of paruterine organs. The ripe eggs have a delicate shell, as appears to be the case in the Acoleidæ generally.

Naturally I have endeavoured to ascertain how far my species

resembles *Bertia* (now written *Bertiella*) *americana*, a species described by Stiles \* from the same genus *Erethizon*, and previously assigned by the American helminthologist to the genus *Andrya*. This species, which is possibly, according to Stiles, identical with *Tenia laticephala* of Leidy †, is regarded by v. Janicki ‡ to be identical with his *Schizotenia*.

Text-figure 8.

*Monacocestus erethizontis*.

Transverse section showing the retiform uterus (*ut.*).

*ci.* Cirrus-sac. *w.v.* Water-vascular tube.

At first sight of the figures given by Stiles in explanation of this species, I was disposed to think that it might be identical with that which I describe in the present paper. For example, the male pores alternate with absolute regularity from right to left in segment to segment, and the very early development of

\* Proc. U.S. Nat. Mus. xix, 1897, p. 165.

† Proc. Ac. Sci. Philad. 1855, p. 443.

‡ Zool. Anz. xxvii, 1904, p. 782.

the sexual organs is as in my species. The drawing\* showing this alternation does not clearly represent the female ducts; but they are shown in a figure of a transverse section†. I infer them to be present in "*Bertia americana*," though no particular and detailed mention of them is made in the text. The shape of the uterus, however, and the extreme narrowness of the segments, are sufficient to prevent any confusion between the two species. *Tenia pectinata*, described by Cobbold‡ from the same animal, is

Text-figure 9.

*Monacocestus erethizontis.*

Horizontal section showing the retiform uterus (*ut.*).

*r.s.* Receptaculum seminis. *w.v.* Water-vascular vessel.

too imperfectly known to permit of a comparison; moreover, it has unilateral genital pores, which are fatal to such a comparison.

The question may arise—are not my specimens perhaps abnormal? Von Janicki§ has lately directed attention to two species of *Hymenolepis* in which the genital pores are absent; and at the same time Wolffhügel|| has made similar observations upon a species of *Bertiella*. These facts are applied by v. Janicki

\* Stiles, *loc. cit.* pl. x, fig. 7.

† Stiles, *loc. cit.* pl. x, fig. 9.

‡ Can. Nat. & Geol. vii. 1862, p. 394.

§ CB. Bakt. u. Paras. xxxvi. 1904, p. 222.

|| Berliner tierärztl. Wochenschr. 1904 (quoted by v. Janicki and Fuhrmann).

to Fuhrmann's genus *Aporina*, among the characters of which genus is the lack of these pores. Fuhrmann, however, has pointed out\* that even if in the future examples of *Aporina alba* be met with in which the sexual ducts reach the exterior, the genus *Aporina* will not be invalidated thereby. I may use the same argument with regard to the species of Cestode which I describe in the present paper. But if I were compelled to ignore the rudimentary vagina, the genus would have to be placed in the subfamily Anoplocephalinae of the family Anoplocephalidae, though it would remain distinct.

*Comparison with Shipleya inermis Fuhrmann.*

Although at first sight, and indeed after some study, I was disposed to place the present species in the same genus as *Shipleya*, and even to consider the possibility of the two forms being identical, I am no longer able, after a more profound study of this species, to identify even generically the two forms referred to. It is remarkable, however, that in pursuing my supposed new species through the dichotomous table of Mr. Ransom I arrived at the genus *Shipleya*, the only difference apparently being the lack of spines upon the cirrus in my species. A reference to Fuhrmann's original description of *Shipleya inermis* shows, however, that there are other differences, and of importance. *Shipleya*, like other Acoleide, has a body-wall which is traversed by a complicated series of muscles. Outside of the inner transverse muscles is a double row of large bundles; outside of this again are four separate and very thin layers of transverse fibres, between each of which is a layer of longitudinal fibres. Such a section is figured by Fuhrmann. In my species, on the other hand, there is but a single and the usual layer of transverse fibres, outside of which is a layer of singly disposed longitudinal fibres, an arrangement in marked contrast to that of *Shipleya*.

In the second place, although my species from *Erethizon* has a large cirrus-sac, this organ is not so large as in *Shipleya*, where it measures no less than one millimetre in length and is, furthermore, covered by diagonal fibres. In my species the fibres have the arrangement described above on p. 1045. There is, however, in both species the accurate alternation in the position of the genital apertures. But we shall see directly that another tapeworm, more probably allied to my species, shows the same regular alternation of these pores from right to left side of the body. I do not think it likely that I have failed to see the spines upon the cirrus if they were really present and like those of *Shipleya*; for Fuhrmann described these spines as arranged in three rows and very like the thorny spines of the Acanthocephala. I have seen nothing of the kind, though the cuticle covering the organ is composed of almost separate rod-like spinules. These, however, are closely set and in contact,

\* Zool. Jahrb., Suppl.-Bd. x. 1908, p. 39.

and cannot be compared with spines such as I infer to exist in *Shipleya*. The last-mentioned genus does not appear to possess testes in the same segments as those which contain the ripe female sexual products; Fuhrmann did not see those gonads but presumed that they were to be found in earlier segments. Now in my species the testes are obvious and numerous in very many segments. Prof. Fuhrmann, with his experience of the structure of Cestodes, could not have missed them were they so plentifully present in *Shipleya inermis*. This is a most important difference between the two forms, and one which marks out the genus *Shipleya* as having retained to some extent the dioecious nature of its ally *Diæococestus*. There is no trace of such a state of affairs in my species. It is doubtless of minor importance to point out that the receptaculum in *Shipleya* has a crenate outline and is a small sac, while in my species it is rather large and of circular contour. Also the vitelline gland of my species is displayed in the same horizontal section with the ovary, and therefore does not lie entirely dorsal to it, as is stated to be the case in *Shipleya*. Finally, it is rather remarkable that there should be so close a likeness between the uterus in the two forms. It has in both a nearly annular shape, being incomplete however on one side. The uterus persists in both species, and is not replaced by anything in the nature of a paruterine organ. This fact, coupled with the character of the female generative system, leads me to place my species in the neighbourhood of this genus *Shipleya*, but other details of anatomy forbid their reference to the same genus.

The species described in this paper therefore differs from *Shipleya* in the following assemblage of characters:—

- (1) *The muscular layers of the body-wall are feeble.*
- (2) *There are no papillæ on the scolex and no apical depression.*
- (3) *The water-vascular tubes have no ramifications.*
- (4) *The testes are numerous in all segments until those in which the uterus is developed, and form rows right across the proglottids.*
- (5) *Although the vagina comes to be aborted it is fully developed in the most anterior segments, and there are traces of the terminal part for some way back in the shape of a sac opening on to the exterior in front of the cirrus.*
- (6) *The cirrus has no spines upon it.*
- (7) *The uterus forms a network.*
- (8) *The vas deferens is dilated into a vesicula seminalis of peculiar form.*

As the definitions of genera among the Cestoidea go, these characters are, as it appears to me, quite sufficient to allow of generic separation. They are also accompanied by a few minor differences, such as the form of the receptaculum seminis, and also by some minor points of likeness, such as size and absence of neck and regular alternation in genital pores.

The following characters will define the new genus, and the name will suggest its affinity with the Acoleidæ:—

**MONÆCOCESTUS**, gen. nov.

*Scolex unarmed; proglottids not longer than broad. Genital pores regularly alternating. Water-vascular tubes two pairs lying side by side, connected by transverse vessel from inner tubes in each proglottid; no network. Longitudinal muscles feebly developed, without bundles. Generative organs visible in first or second proglottid; first genital pore in segment 6. Testes numerous in transverse rows posteriorly, within area bounded by water-vessels; sperm-duct at first very wide and covered by glandular cells, after this short and narrow, without coil or vesicula seminalis; cirrus-sac large and very muscular, cirrus unarmed. Ovary curved in front of smaller vitelline gland. Vagina present in a few early segments, later aborted, with exception of spherical receptaculum seminis. Uterus retiform, meshwork later tending to confluence. Eggs with delicate shell.*

For the present the above definition will have also to serve for the new species, which I call *Monæcocestus erethizontis*, sp. n.



## EXHIBITIONS AND NOTICES.

October 27, 1914.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President,  
in the Chair.

The SECRETARY read the following report on the Additions made to the Society's Menagerie during the months of June, July, August, and September, 1914 :—

## JUNE.

The registered additions to the Society's Menagerie during the month of June were 177 in number. Of these 84 were acquired by presentation, 42 by purchase, 15 were received on deposit, 1 in exchange, and 35 were born in the Gardens.

The number of departures during the same period, by death and removals, was 177.

Amongst the additions special attention may be directed to :—

1 Anoa (*Anoa depressicornis*) ♂, from Celebes, presented by Willoughby Smith on June 4th.

1 Blesbok (*Damaliscus albifrons*), born in the Menagerie on June 18th.

3 Gemsbok (*Oryx gazella*) ♂ ♂ ♀, from the Kalahari, new to the Collection, purchased on June 2nd and 3rd.

1 Panolia Deer (*Cervus eldi*) ♂, from Rangoon, presented by H. L. Holman Hunt, F.Z.S., on June 13th.

1 Vicuña (*Lama vicugna*) ♀, from Peru, presented by G. Noel Clarke, F.Z.S., on June 12th.

1 Peruvian Tree-Porcupine (*Coendu bicolor*), from Peru, new to the Collection, deposited on June 3rd.

2 Firecaps (*Cephalopyrus flammiceps*) and 1 Velvet-fronted Nuthatch (*Sitta frontalis*), from India, both new to the Collection, presented by Alfred Ezra, F.Z.S., on June 12th and 14th.

2 Maximilian's Parrots (*Pionus maximiliana*), from Brazil, presented by the Marquess of Tavistock, F.Z.S., on June 18th.

2 Cotton Teal (*Nettion coromandelianus*), from India, presented by Hubert D. Astley, F.Z.S., on June 29th.

1 Rufous-crowned Ground-Cuckoo (*Coua ruficeps*), from Madagascar, new to the Collection, purchased on June 9th.

1 Arizona Snake (*Coluber arizonæ*), from N. America, new to the Collection, purchased on June 29th.

## JULY.

The registered additions to the Society's Menagerie during the month of July were 277 in number. Of these 93 were acquired by presentation, 81 by purchase, 60 were received on deposit, 9 in exchange, and 34 were born in the Gardens.

The number of departures during the same period, by death and removals, was 239.

Amongst the additions special attention may be directed to:—

1 Lesser Kudu (*Strepsiceros imberbis*) ♂, from Berbera, presented by Arnold Hodson on July 28th.

1 Cape Ant-bear (*Orycteropus capensis*), from S. Africa, purchased on July 1st.

2 Canadian Beavers (*Castor canadensis*), born in the Menagerie on July 1st.

1 Sanday Island Vole (*Microtus sandayensis*), from Sanday Island, N. Orkneys, new to the Collection, presented by W. R. Ogilvie-Grant, F.Z.S., on July 11th.

1 Black-necked Stork (*Xenorhynchus asiaticus*), from India, purchased on July 28th.

1 Great Courlan (*Aramus giganteus*), from Cuba, new to the Collection, purchased on July 4th.

1 Swainson's Hawk (*Gampsonyx swainsoni*), from S. America, new to the Collection, purchased on July 27th.

1 Australian Ground-Thrush (*Oreocincla lunulata*), from New South Wales, new to the Collection, purchased on July 1st.

1 Blue-headed Rock-Thrush (*Petrophila cinclorhyncha*), from the Himalayas, new to the Collection, presented by Alfred Ezra, F.Z.S., on July 27th.

1 Flame-breasted Robin (*Petrarca phoenicea*), from New South Wales, new to the Collection, presented by Alfred Ezra, F.Z.S., on July 1st.

1 White-fronted Chat (*Ephthianura albifrons*), from New South Wales, new to the Collection, purchased on July 1st.

2 Scarlet-breasted Robins (*Petrarca leggi*), from New South Wales, new to the Collection, deposited on July 17th.

2 White-shouldered Caterpillar-eaters (*Lalage tricolor*), from New South Wales, new to the Collection, presented by Alfred Ezra, F.Z.S., on July 1st.

5 Malachite Sun-birds, 2 ♂ and 3 ♀ (*Nectarinia famosa*), from South Africa, new to the Collection, deposited on July 8th.

4 Lesser Double-collared Sun-birds (*Cinnyris chalybeus*), 2 ♂, 2 ♀, from South Africa, new to the Collection, deposited on July 8th.

1 Friar-bird (*Tropidorhynchus corniculatus*), from New South Wales, new to the Collection, purchased on July 1st.

2 Banana-Quits (*Certhiola flaveola*), from the West Indies, new to the Collection, deposited on July 8th.

1 Collared Lizard (*Crotaphytus collaris*), from Western United States, new to the Collection, purchased on July 4th.

1 Giant Monitor (*Varanus giganteus*), from Australia, new to the Collection, deposited on July 1st.

2 Striolated Skinks (*Egernia striolata*), from Australia, new to the Collection, purchased on July 4th.

## AUGUST.

The registered additions to the Society's Menagerie during the month of August were 200 in number. Of these 120 were acquired by presentation, 32 were received on deposit, 17 in exchange, and 31 were born in the Gardens.

The number of departures during the same period, by death and removals, was 224.

Amongst the additions special attention may be directed to:—

1 Kordofan Giraffe (*Giraffa camelopardalis*) ♂, born in the Menagerie on August 12th.

4 New Zealand Geckos (*Hoplodactylus pacificus*), 3 Moco Skinks (*Lygosoma moco*), from New Zealand, and 1 Slender Skink (*Lygosoma tenue*), from Australia, all new to the Collection, deposited on August 6th.

1 Smoky Snake (*Tropidonotus fuliginoides*) and 1 Burrowing Viper (*Atractaspis irregularis*), from Sierra Leone, both new to the Collection, presented by Guy Aylmer, F.Z.S., on August 6th.

## SEPTEMBER.

The registered additions to the Society's Menagerie during the month of September were 130 in number. Of these 56 were acquired by presentation, 51 by purchase, 11 were received on deposit, 6 in exchange, and 6 were born in the Gardens.

The number of departures during the same period, by death and removals, was 161.

Amongst the additions special attention may be directed to:—

1 White-bearded Gnu (*Connochætes albojubatus*), born in the Menagerie on September 28th.

2 Grey-tailed Fruit-Pigeons (*Osmotreron griseicauda*), from Java, new to the Collection, presented by the Marquess of Tavistock, F.Z.S., on September 18th.

A Collection of Birds from New Guinea, the Aru Islands, etc., acquired by purchase on September 11th, and containing Greater Birds-of-Paradise (*Paradisæa apoda*), a Lesser Bird-of-Paradise (*P. minor*), King Birds-of-Paradise (*Cicinnurus regius*), and the following species new to the Collection:—

1 Fairy Bluebird (*Irena turcosa*) from Java, 2 Blue-eyed Ravens (*Macrocorax fuscicapillus*), 1 New Guinea Pitta (*Pitta nova-guineæ*), and 3 Duperrey's Megapodes (*Megapodius duperreyi*) from the Aru Islands; and 2 Pied Egrets (*Notophoxya flavirostris*) from South-west New Guinea.

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Mr. R. H. BURNE, M.A., V.P.Z.S., exhibited a number of preparations showing some adaptations for the nourishment of the embryos of Elasmobranchs.

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MR. R. E. SAVAGE exhibited two abnormal Herrings (*Clupea harengus*), taken by trawl in the North Sea. The first specimen had neither pelvic fins nor girdle (pelvic bones). The usual position of base of fins was indicated externally by the presence of the characteristic elongated scales. The usual musculature was present internally. The second specimen lacked the left pelvic fin and pelvic bone; the musculature was complete.

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MESSRS. E. HERON-ALLEN, F.L.S., F.Z.S., and ARTHUR EARLAND, F.R.M.S., read a paper on the Foraminifera of the Kerimba Archipelago, obtained by Dr. J. J. Simpson in the years 1907-8.

This paper has been published in the 'Transactions.'

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MR. W. L. DISTANT communicated his Report on the Rhynchota collected by the Wollaston Expedition in Dutch New Guinea.

This paper has been published in the 'Transactions.'

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### November 10, 1914.

Prof. E. W. MACBRIDE, M.A., D.Sc., F.R.S., Vice-President,  
in the Chair.

The SECRETARY read the following report on the additions to the Society's Menagerie during the month of October 1914:—

The number of registered additions to the Society's Menagerie during the month of October was 290. Of these 268 were acquired by presentation, 15 were received on deposit, 6 in exchange, and 1 was born in the Gardens.

The number of departures during the same period, by death and removals, was 207.

Amongst the additions special attention may be directed to:—

A Collection of Birds presented by Sir Walter Gilbey, Bart., F.Z.S., on October 12th, consisting of a Hunstein's Bird-of-Paradise (*Diphyllodes hunsteini*) from South-east New Guinea, a Hildebrandt's Starling (*Spreo hildebrandti*) from East Africa (new to the Collection), a Hunting Crow (*Cissa chinensis*) from India, and a number of other rare birds.

A Collection of Birds from Chili, presented by Geo. H. F. Duncan, F.Z.S., on October 22nd, containing 10 Cayenne Lapwings (*Belonopterus cayennensis*), 2 Chilian Sea-Eagles (*Gera-  
noæetus melanoleucus*), 5 Gay's Finches (*Phrygilus gayi*), and others.

2 Red-necked Phalaropes (*Phalaropus hyperboreus*), from Iceland, new to the Collection, presented by W. H. St. Quintin, F.Z.S., on October 8th.

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The SECRETARY exhibited a photograph showing Oysters growing upon mangroves at Lobito Bay, Portuguese West Africa.

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Mr. R. H. BURNE, M.A., V.P.Z.S., exhibited some paraffin Simulacra of Molluscan and other Shells made accidentally by Dr. C. V. Ariens Kappers while embedding objects for the microtome. During this process, paraffin in a molten state inadvertently escaped from the mould and set in the shell-forms shown, probably owing to distorted crystallization.

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Mr. H. R. HOGG, M.A., F.Z.S., read his Report on the Spiders collected by the British Ornithologists' Union and Wollaston Expeditions in Dutch New Guinea.

This paper will be published in the 'Transactions.'

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### *Birth of a Porpoise at the Brighton Aquarium.*

Mr. LEWIS H. JAMES, B.A., F.Z.S., communicated the following notes upon the birth of a porpoise at the Brighton Aquarium :—

On the 26th May, 1914, a female porpoise (*Phocæna communis*) was caught in a kettle-net at Dungeness. She was transferred to a sluice immediately she was landed and left there for a short time. She was then seen to be in an advanced stage of pregnancy. Later, she was transferred by road and rail to Brighton Aquarium, where she was placed in a tank containing 110,000 gallons of sea-water. During the journey the porpoise was wrapped in wet blankets and the eyes and nares were frequently sponged with sea-water. On being placed in the tank, she seemed in good condition and swam well.

On the afternoon of Sunday, 31st May, the porpoise seemed to be in great pain. She swam to and fro in the tank, resting at intervals on the surface. This was about 3.15 P.M., and from this time typical labour movements set in. While lying at the surface of the tank she made straining movements by arching her back, and in about half an hour the first signs of the offspring appeared in the form of the tail. Labour was now very strained, and the mother appeared in great pain, probably owing to the fact of a breach presentation. About one-half of the young was forced out by spasmodic contractions, while presentation was completed by a final forced contraction. The whole process lasted from 3.15 to 5.50 P.M.

The cord was still attached to the mother, but was soon broken after she had swum 20 yards or so.

After the birth of the young, which was a still-born male, the mother was much easier, and before long was swimming about normally. After about five hours, the first signs of the after-birth appeared and was successfully passed  $4\frac{1}{2}$  hours later. As described to me by the superintendent who witnessed it, the after-birth was "a chamois leather-like paunch" and weighed  $1\frac{1}{2}$  lbs. Unfortunately it was thrown away. There were slight straining-movements during the passing of the placenta, but very little bleeding.

The young weighed 7 lbs. approximately and measured 2 feet 2 inches. It was perfectly formed, and its skin was soft, resembling a kid glove.

The mother died on Wednesday, 10th June—probably, if she had been allowed to remain in the sluice for a time, the foetus would have turned successfully, and both mother and young would have been saved. On the journey between Lewes and Brighton the mother passed a certain amount of foaming blood through her nostrils, but when placed in the tank seemed to be perfectly fit.

The mother and young are at present at Brighton to be mounted for the local Museum.

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### *Pine and Beech Martens.*

(Text-figures 1-4.)

Mr. R. I. Pocock, F.R.S., F.L.S., F.Z.S., Curator of Mammals, gave an exhibition, illustrated by lantern-slides, to show some newly noted points of difference between the Pine Marten (*Martes martes*) and the Beech Marten (*Martes foina*) and remarked:—"The cranial and dental differences between these two species, pointed out by Mr. E. R. Alston in 1879 (P. Z. S. 1879, p. 468), are well known, and have been recently restated by Miller (Cat. Mamm. Western Europe, 1912). Alston scarcely dealt with external characters, and Miller, when describing *M. foina*, dismissed them as follows: "external form as in *M. martes*, but fur of less fine quality; colour usually more greyish or drab than in *M. martes* and seldom with the rich brown tints of [that] species, the throat patch never strongly tinged with yellow." From this it might be inferred that the only external differences between the two species are found in the texture and colour of the fur. That the differences in the structure of the ears and feet I am about to describe were overlooked by Miller, must presumably be attributed to his working with dried skins and not with specimens preserved in alcohol. The material upon

which my conclusions are based are two examples of *M. martes* and one of *M. foina*, sent from France to the Gardens for Mr. Thompson Seton. They were not quite adult, but practically of the same size. They died upon the same day in September, after being kept under precisely similar conditions, and were preserved in alcohol for the investigation of external characters.

*Ears*.—All the Pine and Beech Martens that have been exhibited within my recollection in the Gardens could be distinguished at once, when seen side by side, by the difference in the

Text-figure 1.



Pine Marten (*Martes martes*).

size of the ears (text-figs. 1 & 2). In the Pine Marten these organs are relatively longer and wider and appear in consequence to be more pricked, so that the animal looks more alert than the Beech Marten. Moreover, the narrower ears in the latter make the intervening space on the crown wider, and the whole head has a broader look than in the Pine Marten. The actual differences in dimensions in the ears are shown in the subjoined table of measurements (p. 1068). In details of structure the ears are much alike, as might perhaps be expected. In both species there

is a very distinct lobe upon the "antihelix"\*; but whereas in *M. foina* this lobe is thick and fleshy, in *M. martes* it is compressed and scale-like. Finally, the integumental flap at the back of the ear, like the pinna of the ear itself, is longer in *M. martes* than in *M. foina* (text-fig. 3).

It is probable that the length and breadth of the ears will be found to vary locally in both *M. martes* and *M. foina*; but many more measurements than have as yet been taken must be recorded before the average difference in size of these organs between the two species can be established.

Text-figure 2.

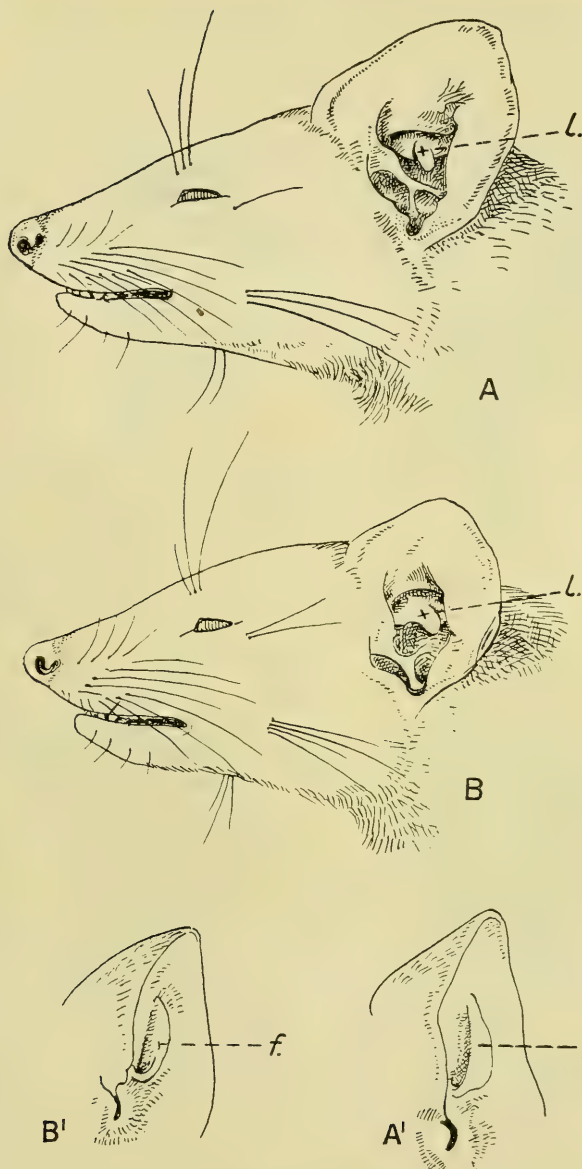


Beech Marten (*Martes foina*).

*Feet.*—From the appearance of living animals I supposed at one time that *M. martes* was a longer legged form than *M. foina*; but measurements of specimens in the flesh show that this is not so. The feet are apparently of practically the same shape in the two. The four main digits are separated by subequal intervals and webbed, as in the Canidæ, practically to the level of the proximal margins of the digital pads. These digits, moreover, are very nearly symmetrical in the sense that the second and fifth and the third and fourth toes are respectively almost

\* The *plica principalis* of Boas, 'Ohrknorpel und ausserer Ohr,' 1912.

Text-figure 3.



A. Head of *M. martes*, with ear fully expanded.  
*l.* Lobe on antihelix.

B. The same of *M. foina*.

A'. Side view of ear of *M. martes*, with the posterior half folded forwards to show the flap (*f*) on the back of it.

B'. The same of *M. foina*.

on a level. The area of the sole between the plantar and digital pads is thickly hairy except for narrow naked streaks, visible when the hairs are parted, running forwards from the plantar pad towards the digital pads. The area behind or above the plantar pad is also covered with hair, except that in the fore foot there are two carpal pads, a larger (hypothénar) on the ulnar side of the middle line and a much smaller (thénar) on the radial side. These two carpal pads are separated by a considerable space from the plantar pad and by a very narrow hair-covered space from one another. The main portion of the plantar pad of both fore and hind feet is nearly bilaterally symmetrical, consisting of the three normal lobes corresponding to the four principal digits, but behind the inner lobe corresponding to the second digit there is an accessory lobe or pad corresponding to the first digit. The digital pads and the lobes of the plantar pads are concentrically striate, and the summits of the lobes of the plantar pad on the hind foot are crowned with a cluster of small close-set papillæ\*.

In the particulars described above the feet of the two species are alike; but so far as the pads are concerned considerable differences may be noticed. The pads of *M. foina* may be described as normal in size; the digitals are broadly elliptical and a little longer than and nearly twice as wide as those of *M. martes*. The plantar and carpal pads also are larger and encroached upon by hair to a much lesser extent in *M. foina* than in *M. martes*. In the hind foot of *M. martes* indeed the plantar pad may be said to be reduced to four striate tubercles joined by narrow strips of hairless, soft, unstriated integument. These differences are shown in the figures and in the subjoined table of measurements (p. 1068). The smaller size of the pads in *M. martes* makes the digits appear to be longer than in *M. foina*, but there does not seem to be actually any difference in this respect between the two species (text-fig. 4).

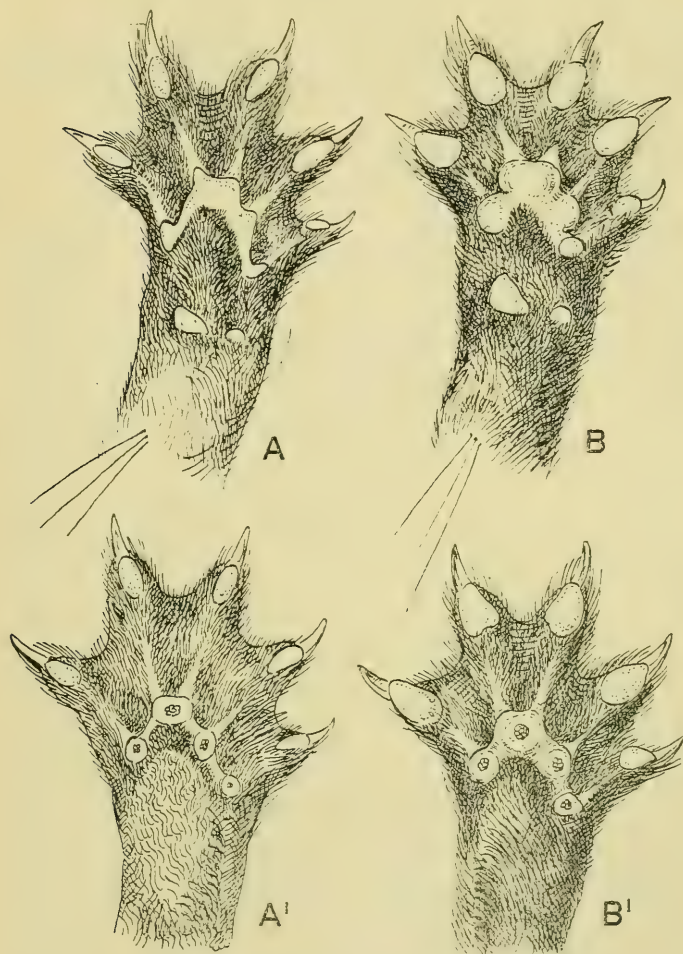
The hair on the metatarsal area is much thicker and woollier in texture in *M. martes* than in *M. foina*.

I do not suppose that the distinguishing points in the pads above pointed out will be found to be absolutely constant in all specimens of these two Martens from different localities and at all seasons of the year; but I strongly suspect that closely corresponding differences will prove to obtain between specimens collected in the same countries or latitudes at the same season of the year. It is possible that in both species the pads are more overgrown with hair in northern than in southern individuals, and in winter than in summer. These points have, I believe, yet to be worked out in detail. But it was that possibility I had in mind when stating that the examples I examined, all probably Central European, died upon the same day and had

\*. Martens are prodigious jumpers, and the papillæ on the plantar pads probably obviate the likelihood of slipping during their leaping pursuit of Squirrels through the trees.

been previously kept for several weeks under precisely similar conditions\*.

Text-figure 4.



A. Fore foot of *M. martes*.  
A'. Hind foot of the same.

B. Fore foot of *M. foina*.  
B'. Hind foot of the same.

\* Miller's statement (*op. cit.* p. 368) that the feet of *M. martes* are densely furred throughout in winter is certainly not always, if it is sometimes, true. It is contradicted by the skins of two Cumberland specimens, killed on Dec. 5th, and preserved in the British Museum. The pads in these are quite obviously bare and not even concealed, much less overgrown, by the fur of the sole.

Subjoined are the principal measurements of examples of the Pine and Beech Martens, elucidating the points above described.

|  | <i>M. martes.</i> | <i>M. foina.</i> |
|--|-------------------|------------------|
| Length of head and body .....                        | 380 mm.           | 380 mm.          |
| „ tail without tuft .....                            | 187 „             | 187 „            |
| „ hind leg from hock .....                           | 81 „              | 81 „             |
| „ front leg from elbow .....                         | 107 „             | 107 „            |
| „ ear from notch .....                               | 41 „              | 37 „             |
| Width of ear fully spread .....                      | 37 „              | 31 „             |
| Length of median lobe of plantar pad of fore foot... | 5 „               | 8 „              |
| Width of ditto .....                                 | 8 „               | 10 „             |
| Width of pad excl. pollical lobe .....               | 15 „              | 16 „             |
| Length of 3rd digital pad .....                      | 7 „               | 9 „              |
| Width of ditto .....                                 | 3 „               | 5 „              |
| Length of larger carpal pad .....                    | 3 „               | 6 „              |
| Width of ditto .....                                 | 5 „               | 6 „              |

The dimensions in millimetres of four specimens published by Miller may be compared with those set forth above:—

|                               | <i>M. martes.</i> |          | <i>M. foina.</i> |                              |
|-------------------------------|-------------------|----------|------------------|------------------------------|
|                               | Como.             | Minorca. | Switzerland.     | Crete<br>( <i>bunites</i> ). |
| Length of head and body ..... | 470               | 430      | 453              | 403                          |
| „ tail .....                  | 235               | 230      | 260              | 255                          |
| „ hind foot.....              | 94.6              | 87       | 85               | 79                           |
| „ ear .....                   | 42                | 45       | 34               | 39                           |

Making the necessary allowances for errors in small respects and for variations due to the “personal equation” of the collectors, this table bears out on the whole the contention that the ears are longer in *M. martes* than in *M. foina*. The Swiss specimen of the latter, an adult male from St. Gallen, has remarkably short ears, whereas the Cretan example, regarded by Miller as representing a distinct species (*M. bunites*), has these organs a little longer than the specimen of *M. foina* measured by myself, although, judging by the length of the hind foot, it was a smaller animal\*. Miller described it as a “young adult male.” It must be remembered in this connection that the ears in young mammals are always relatively longer than in the adults and probably do not increase appreciably in length after the subadult stage is reached. Clearly, however, the average length of the ear in the three examples of *M. foina* is much less than the average length of the ear in the three examples of *M. martes*, the dimensions being approximately 37 and 43 respectively.”

\* The shortness of the tail and of the head and body in my examples is probably attributable to the shrinkage of specimens preserved in alcohol, which could not be properly straightened.

November 24, 1914.

Prof. E. A. MINCHIN, M.A., F.R.S., Vice-President,  
in the Chair.

Mr. E. T. NEWTON, F.R.S., F.Z.S., exhibited a series of bones of animals showing indications of natural repair, and a number of teeth of a female Sperm-Whale (*Physeter macrocephalus*).

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*Purpose and Intelligence in the Foraminifera.*

MESSRS. E. HERON-ALLEN, F.L.S., F.Z.S., and ARTHUR EARLAND, F.R.M.S., discussed the Phenomena of "Purpose" and "Intelligence" exhibited by the Arenaceous Foraminifera in the construction of their tests. They observed that W. B. Carpenter had stated in 1885 that the highest development of function and behaviour of protoplasm in the Protozoa was to be found in the study of the Foraminifera, and they exhibited slides of porcellaneous and hyaline species, calling attention to the fact that of two groups of the same Zoological Order, constructed of the same simple protoplasmic element and living under similar conditions, one group secretes calcium carbonate and the other strontium sulphate from the same sample of sea-water, for the construction of their shells.

The behaviour of many species of Arenaceous Foraminifera in constructing their tests reveals a development of "purpose" amounting to what in the Metazoa would be termed "intelligence." This display of intelligence and purpose takes two forms: (i) The exclusive selection of certain materials out of a preponderating mass of other and more readily utilizable materials; and (ii) the manner in which those materials are used. This latter is subdivided under two heads—(a) to meet the requirements of the organism in adapting itself to environmental circumstances, and (b) to protect itself against the attacks of parasitic worms and other enemies.

Lantern-slides were shown, and the actual specimens exhibited under microscopes upon the table, to illustrate the following phenomena:—1. The selection of magnetite by *Haplophragmium agglutinans* and of topaz and garnet by *Verneuilina polystropha*, for the construction and decoration (?) of their tests. 2. The utilization of foraminiferal shells by certain abyssal worms, and the method employed by *Pectinaria auricoma* in "laying" fragments of sponge-spicules of even length in the construction of its tube. 3. *Psammosphaera parva* Flint, which builds a monothalamous shell of sand-grains round a long sponge-spicule, which is used as a "catamaran" spar to buoy it up upon the bottom ooze. 4. *Psammosphaera bowmani* Heron-Allen & Earland, which constructs its shell of flakes of mica cemented

together at their edges to form a transparent polyhedral test. 5. *Psammosphera rustica* H.-A. & E., which constructs a polyhedral test between long "catamaram" spicules, filling the interspaces with fragments of spicules of graduated length and occasionally using a triaxial spicule to fill an awkward space or angle. 6. *Nouria harrisii* H.-A. & E., which supports itself, aperture uppermost, upon the mud by means of spicules projecting at the aboral end of the test. 7. *Haliphysema tumanowiczii* Bowerbank, which protects its aperture from parasitic worms with an investment of projecting spicules. 8. *Crithionina pisum* Goës, var. *hispid*a Brady, 9. *Pilulina jeffreysii* Carpenter, and 10. *Hyperammina ramosa* Brady, which protect themselves with a close investment of spicules all over their shells. 11. *Marsipella cylindrica* Brady, which protects its aperture with a crown of loosely aggregated spicules. 12. *Marsipella spiralis* H.-A. & E., which arranges the spicules of which it is constructed in a left-handed spiral to give tensional strength. 13. *Technitella legumen* Norman, which constructs its shell of fragments of spicules in two layers, the inner layer being laid at right angles to the outer. 14. *Technitella thompsoni* H.-A. & E., which selects from the environmental material for the construction of its test nothing but the perforated plates of an ophiurid or echinoderm.

In the opinion of the authors, "purpose" and "intelligence" are revealed by these phenomena. If they depended on surface-tension, all the individuals in a dredging would exhibit the same phenomena, and the theory of natural selection resulting in the survival of the fittest is met by the reply that these selective and purposive individuals constitute a marked minority in the dredgings in which they are found.

An interesting discussion followed, in which, amongst others, Sir H. H. Howorth, F.R.S., Sir E. Ray Lankester, F.R.S., and the Secretary took part.

#### *Egg of the New Guinea Rifle-bird.*

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited an egg of the New Guinea Rifle-bird (*Ptilorhis intercedens*) which had been laid in the Society's Gardens in July last. The bird that laid it belonged to Mr. E. J. Brook, F.Z.S., who had kindly lent it in the hope that it might pair with a male belonging to the Society. While in Mr. Brook's aviaries in Scotland, this bird paired with a male of its species, and in 1911 and 1912 constructed a nest and laid eggs, but in both cases they were infertile.

The birds were placed last spring in the Summer Aviary, where they appeared to do well, and in July the female built a nest, composed of dead leaves and dry grass, in a bush, about five feet from the ground, and laid two eggs. She sat well and was not

disturbed in any way, but about three weeks after the eggs were laid they were apparently thrown out of the nest by the sitting bird, for they were found broken upon the ground. Neither appeared to have been fertilized. The one least damaged was saved.

This is the first instance of any species of Paradise-bird laying in these Gardens, and the eggs laid in Mr. Brook's aviaries were the first ever laid in captivity. The bird that laid these eggs was captured on the nest in New Guinea by Mr. Goodfellow, and the nest and two eggs upon which she was sitting are now in the British Museum.

The egg is very similar to that of the Greater Bird of Paradise (*Paradisaea apoda*), and, so far as we know, characteristic of the whole group. The ground-colour is cream, bold streaks of reddish brown radiating from the larger end and overlaying fainter splashes of pale grey.

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#### *Dental Variations in Mammalian Skulls.*

DR. ROBERT BROOM, C.M.Z.S., exhibited :—

(1) A number of skulls of *Trichosurus vulpecula* illustrating dental variations. Normally upper  $p^1$  is situated 2.5 mm. behind the canine. Two skulls exhibited show it from .5 mm. to 1 mm. behind the canine. One skull shows on the left side  $p^1$  closely pressed against the canine, and on the right side the two teeth fused together. Another skull shows the  $p^1$  entirely absent. In the lower jaw normally the small tooth behind the large incisor is close to it. One jaw shown has the second tooth 2 mm. behind the large incisor. A second jaw has 2 mm. behind the normally placed second tooth a third small tooth, which may be either a third incisor, a canine, or a first premolar.

(2) A skull of *Phascolarctus cinereus* showing in the right lower jaw a small tooth behind the large incisor, resembling in position the second tooth in the mandible of *Trichosurus vulpecula*.

(3) A series of skulls of *Chrysochloris hottentota* and *C. asiatica* illustrating the peculiar loss of teeth found in nearly all sexually mature Moles in the Stellenbosch district, S. Africa. As Dr. Broom pointed out in 1907, *C. hottentota*, when probably two years old and when in full sexual activity, suffers from a disease of the gums, probably pyorrhœa, and the teeth become loose and fall out. The disease appears also to damage the developing second set, which never fully replaces the lost milk set, and hence specimens are found where the disease has been arrested in a practically toothless condition.

It is very interesting to note that these toothless specimens

appear to be in fairly good health. In their stomachs are the remains of worms broken into segments, as in the fully toothed individuals.

Though specimens in a similar condition have been obtained from other parts of S. Africa, they are rare.

*Chrysochloris asiatica* rarely suffers with its jaws, but a specimen was exhibited in which the disease had led to extensive injury to the bone.

(4) A skull of *Chrysochloris hottentota* with only eight teeth in each upper jaw, though there are the normal nine on each side of the lower.

### *A new Thecodont Reptile.*

(Text-figures 1, 2.)

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Dr. BROOM also exhibited the skull of a new type of Thecodont reptile (*Youngina capensis*) from the Upper Permian beds of South Africa, and remarked:—

“Hitherto, though there has been some evidence of the occurrence of primitive Thecodonts in the Karroo beds of Upper Permian age, no satisfactory skull has been known. Some years ago I described the two types, *Heleosaurus scholtzi* and *Heleophilus acutus*, both of Middle Permian age, and Watson is describing another form of the same age which may be allied. Unfortunately, little is known of the skull in any of these types.

The new form which I am exhibiting was found by me at New Bethesda, Cape Colony, in beds which are in the *Cistecephalus* zone, at least 600–1000 ft. below the *Lystrosaurus* zone, and most probably belong to the Upper Permian age.

The specimen consists of the almost perfect skull of a small crocodile-like reptile, with a considerable series of vertebræ, but unfortunately with no satisfactory remains of limbs or girdles.

The skull measures about 60 mm. in greatest length, and is 42 mm. in width. The tip of the snout is missing, but as the anterior ends of the lower jaws are preserved, very little can have been lost.

The orbits, which are situated near the middle of the skull, are large and are directed upwards and outwards. The antero-posterior diameter of the orbit is 17 mm. The interorbital width is about 8 mm.

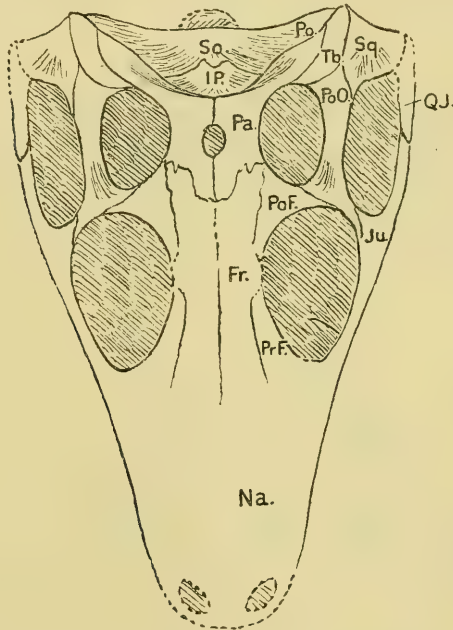
Behind the orbit is an infratemporal fossa slightly smaller than the orbit, and a supratemporal fossa about a third of the size of the infratemporal.

The premaxillaries are lost but must have been small.

The nasals are imperfect and crushed; they are manifestly fairly large. The nostrils must be situated well forward.

The maxilla is long and narrow, and on the right side shows 16 rounded pointed teeth. The complete series is probably about 21, a number evidently having been shed and were being replaced. The posterior end of the maxilla passes under the orbit, and has a long articulation with the jugal.

Text-figure 1.



Upper side of skull of *Youngina capensis*. About  $1\frac{1}{2}$  times nat. size.

Fr., frontal; IP., interparietal; Ju., jugal; Na., nasal; Pa., parietal; Po., Paroccipital; Po.F., postfrontal; Po.O., postorbital; Pr.F., prefrontal; Q.J., quadratojugal; So., supraoccipital; Sq., squamosal; Tb., tabular.

The lacrymal is not well preserved on either side, but is manifestly small.

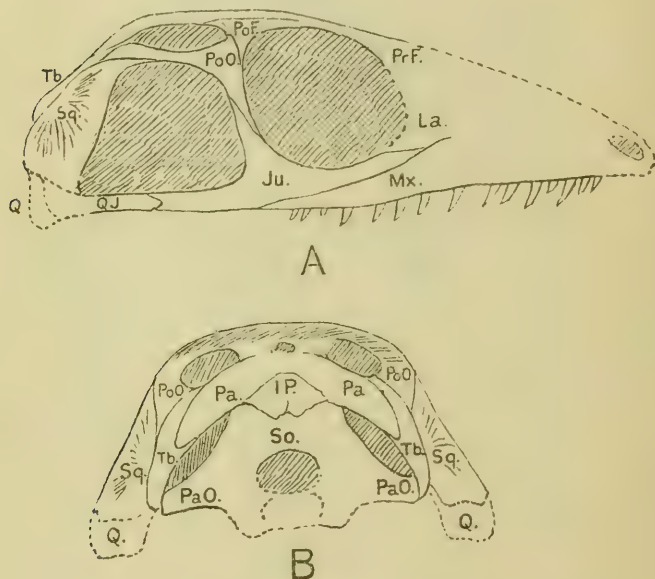
The prefrontal is a fair sized element. It forms the upper and anterior border of the orbit, and, with the postfrontal, nearly shuts out the frontal from the orbit.

The frontal is moderately large. It extends in front a little beyond the plane of the front of the orbit, and behind as far as the plane passing through the front of the pineal foramen.

The jugal is a long triradiating bone. Its anterior process forms the lower border of the orbit, and passes forward between the lacrymal and the maxilla. The ascending process passes up behind the orbit to articulate with the postorbital; while the posterior process forms the lower border of the infratemporal fossa, and lies above and internal to the quadratojugal.

The postfrontal is a small triangular bone which forms the upper and anterior border of the orbit, and the anterior border of the supratemporal fossa. It articulates with the frontal and parietal internally, and the postorbital externally.

Text-figure 2.

A. Side view of skull of *Youngina capensis*. About  $1\frac{1}{2}$  nat. size.B. Occiput of *Youngina capensis*. About  $1\frac{1}{2}$  nat. size.

IP., interparietal; Ju., jugal; La., lacrymal; Mx., maxilla; Pa., parietal; Pa.O., paroccipital; Po.F., postfrontal; Po.O., postorbital; Pr.F., prefrontal; Q., quadrate; Q.J., quadratojugal; So., supraoccipital; Sq., squamosal; Tb., tabular.

The postorbital is moderately large. It forms part of the postorbital margin and most of the bar between the two temporal fossæ. The posterior process is well developed and passes back between the squamosal and the tabular.

The parietals are smaller than the frontals. Between them is a fairly large pineal foramen. The posterior process of the

parietal is directed outwards and backwards, as in lizards and *Sphenodon*, and rests on the bone which I believe to be the tabular.

The structure of the post-temporal region is a little difficult to make out, but as it is well preserved on both sides the difficulty consists largely in distinguishing cracks from sutures, and I think there is practically no doubt but that the elements are as I have figured them. Whether my interpretation of them is correct is, of course, another matter.

Forming the posterior border of the infratemporal fossa is a fair sized triangular bone, which I believe to be the squamosal. It articulates above with the postorbital, and below it probably articulates with the quadratojugal. The quadrate is very largely hidden by it.

With the posterior end of the jugal articulates an element which I believe to be the quadratojugal. Unfortunately its posterior portion is not seen on either side. It cannot be a part of the element which I identify as squamosal. The relations of the quadratojugal, squamosal, and jugal are somewhat similar to those in *Sphenodon*.

Along the upper and posterior side of the squamosal lies another element of considerable size, which I believe to be the tabular. In front it meets the postorbital, and its inner side is partly covered by the posterior process of the parietal. Posteriorly it articulates with the paroccipital (opisthotic).

Behind the parietals and above the supraoccipital is a fair sized and certainly distinct interparietal. Possibly it is paired.

The occiput, though fairly well preserved, does not show the limits of the various elements. The supraoccipital is low and broad; the exoccipitals are probably small, and there are short paroccipitals directed backwards and outwards. Between the sides of the supraoccipital and the tabulars are a pair of narrow fossæ. On the whole the resemblance of the occiput to that of the lizard is considerable, the presence of a distinct interparietal being the only important difference.

The mandibles, though present and complete, have not been cleared of matrix, as it would be difficult to do so without injuring the teeth, and the presence of the mandibles renders it impossible to display the palate.

For this new reptilian type I propose the name *Youngina capensis*, in honour of the late Mr. John Young, LL.D., F.G.S., Under-Curator of the Hunterian Museum, Glasgow University, to whose early assistance and kindly encouragement I am mainly indebted for my interest in palæontology.

Though *Youngina* cannot be placed close to any previously well-known type, we can nevertheless give it a fairly definite place in the reptilian series.

If we exclude the Cotylosauria, the Therapsida, the Chelonina, the Ichthyosauria, and the Plesiosauria, all the remaining orders

may be grouped together as reptiles with two temporal arches or modifications of the same type. In *Sphenodon* we have a simple modification of the type; in the Crocodile another, and in the Lizards a third where the lower arch is lost. Among extinct forms we have many other modifications. The Phytosaurs and Pseudosuchians afford the best known Triassic types, and other varieties of the type are seen in the Gnathodonts and the Dinosaurs. *Youngina* represents a type more primitive than any previously known, and one which is especially important in that it is very near to the ancestral form.

The Pseudosuchian, *Euparkeria*, which I recently described from the South African Upper Triassic beds, bears considerable resemblance to *Youngina* but is very manifestly a much later type. It has lost the large pineal foramen seen in *Youngina*, and the post-temporal region differs considerably through the loss of the tabular, the reduction in size of the squamosal, and the increased development of the quadratojugal and quadrate. Yet such a type as *Euparkeria* might readily be descended from a form like *Youngina*.

*Euparkeria* further represents a type from which the Theropodous Dinosaurs might be derived, but is too far advanced to have been ancestral either to the Sauropoda or Predentata. *Youngina*, on the other hand, retains the characters that we require in the ancestor at least of the Sauropoda, and possibly also of the Predentata.

But the most interesting point in the structure of *Youngina* is the light it throws on the origin of lizards.

No point in reptilian structure has given rise to so many different opinions as the nature of the post-temporal region in lizards. In *Sphenodon* there is no difficulty. There is low down an undoubted quadratojugal, and between this and the parietal a single large bone which is unquestionably the squamosal. In the typical lizards, on the other hand, between the top of the quadrate and the parietal are two small bones, and the difficulty is to determine which is the squamosal. The upper and inner bone has been regarded as the squamosal by Gegenbaur, Baur, Gaupp, Case, and Watson; the lower and outer by Parker, Huxley, Cope, Boulenger, and Williston. Until a year ago I favoured the view of Baur, but the study of the Mosasaur skulls in the American Museum led me to adopt the view of Williston, that the outer bone is the squamosal and the inner the tabular.

About a dozen years ago I made a study of the development of the pterygo-quadrate bar in a number of lizard types, and found that the lower end of the quadrate is fixed to the lower end of the epipterygoid by a small bar of cartilage almost exactly as in *Sphenodon*. So strikingly similar is the condition that it seems extremely probable that there was in the ancestral lizard a lower bar as in *Sphenodon*.

While *Youngina* is certainly not a lizard, it throws very definite

light on the nature of the lacertilian post-temporal bones. The upper arch is formed mainly by the postorbital but partly by a lower bone which I regard as squamosal. Whatever this lower bone is, it is quite certainly the homologue of the outer post-temporal bone of the lizard, and as there is a quadratojugal still lower down, it cannot be the quadratojugal. From its relations to the quadrate, there seems little doubt but that it is correctly identified as the squamosal.

The bone internal to it may be the so-called "supra-temporal," but from its articulating with the paroccipital it seems much more likely to be the tabular.

*Youngina* may be regarded as the type genus of a new family, which may be called Younginidæ, and it must also be placed in a new suborder of the Thecodontia, which may be called the

#### EOSUCHIA.

The Eosuchia may be defined as Thecodont reptiles which have no antorbital vacuity, and retain the interparietal and tabular bones, and have a large pineal foramen."



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